FT32 AND SMALLER TURBINE FLOWMETERS INSTALLATION, OPERATION AND MAINTENANCE MANUAL

EG&G FLOW TECHNOLOGY

MP MASTER
MA28904

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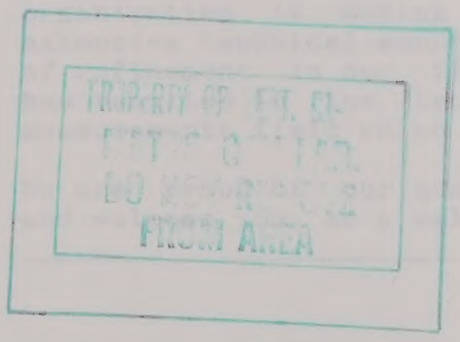

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EG&G FLOW TECHNOLOGY
4250 East Broadway Road
Phoenix, Arizona 85040

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NOTE

Please do not return equipment without a Return Authorization Number.

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READ ALL CAUTION STATEMENTS BEFORE ATTEMPTING TO INSTALL OR OPERATE THIS EQUIPMENT

C A U T I O N

It is VERY IMPORTANT that ALL precautions are taken to insure the safety of operating personnel and observers. These precautions include, but are NOT limited to the following examples:

a. The system operates under pressure and this pressure MUST be relieved before removing the flowmeter or doing any work on the system.

b. The use of ANY toxic, explosive, or otherwise HAZARDOUS fluids require that they be vented to a safe area and the system totally evacuated before performing any work on the system, including changing the flowmeter.

c. The metals used in the construction are slightly porous and will retain traces of fluids used in calibration.

d. The mixing of two relatively safe fluids may result in an instable and unsafe reaction, even in the trace amounts which may be retained in the pores.

e. ALL applicable SAFETY CODES (i.e., NEC, NFPA) must be enforced when installing and/or when using this system. Failure to do so may cause INJURY to personnel.

f. A flowmeter is a precision instrument and may be damaged if a high pressure air hose is used for cleaning the meter or for checking the rotation of the rotor.

g. Pressure should be built up gradually at start up to avoid possible damage by over speeding the rotor.

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1.0 SCOPE

This manual provides information and guidance for the installation, operation and maintenance of the Standard Line Turbine Flowmeters, manufactured by EG&G Flow Technology, Inc.®, Phoenix, Arizona.

2.0 PURPOSE

The contents of this manual are for general information and to describe the operational characteristics of the Standard Line Turbine Flowmeters. This manual does not contain instructions for special applications or factory repairs. Persons who are interested in the theoretical aspects and significant parameters of this or any turbine flowmeter systems, should obtain a copy of "Handbook for Turbine Flowmeter Systems" from EG&G Flow Technology, Inc.® (FTI).

3.0 DESCRIPTION

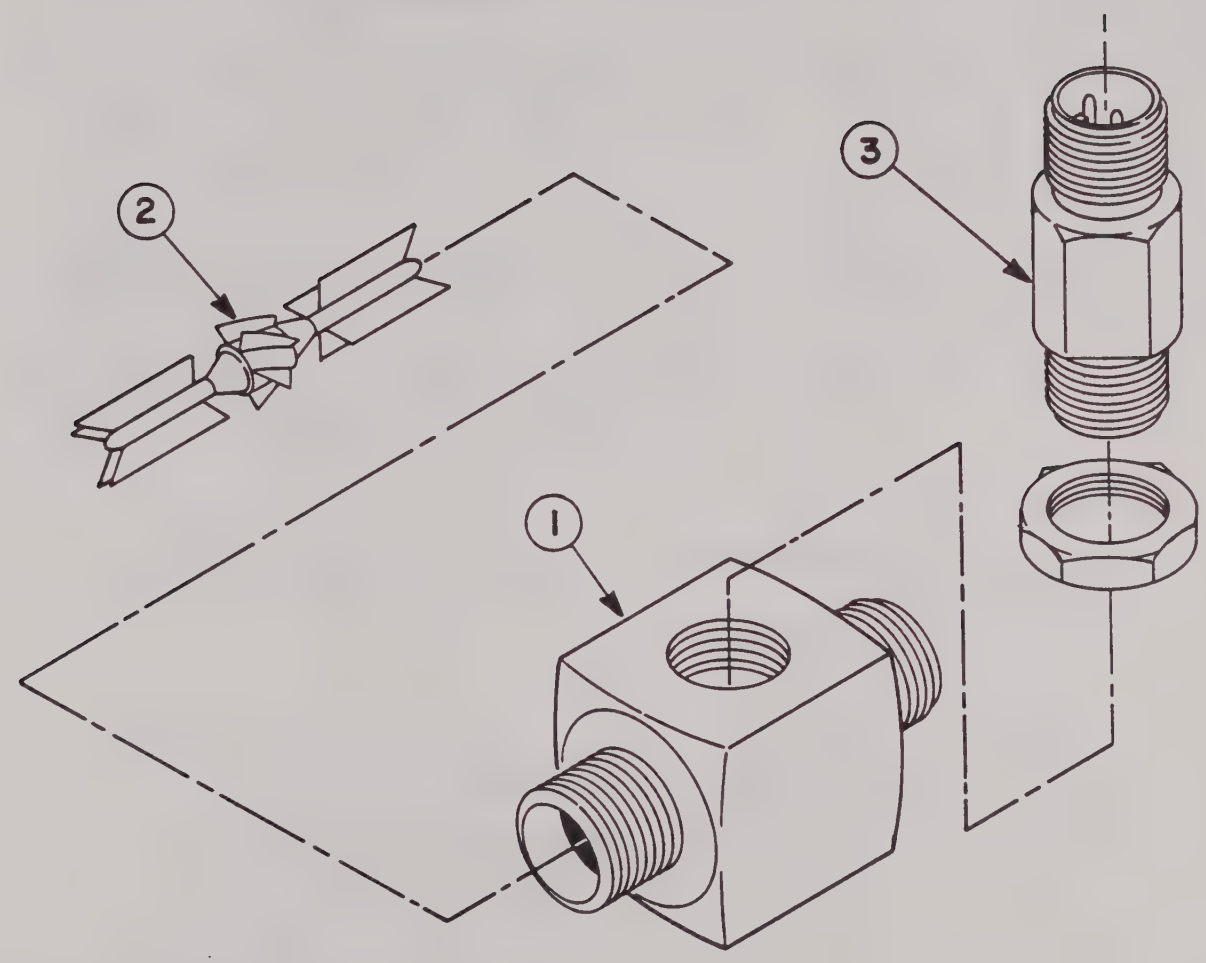
3.1 STANDARD LINE FLOWMETER

3.1.1 The FTI Standard Line Turbine Flowmeter is a volumetric flow measuring instrument. The flow sensitive element is a freely suspended, bladed rotor positioned axially in the flow stream with the flowing fluid pushing against the blades.

3.1.1.1 The rotational speed of the turbine is proportional to the velocity of the fluid. Since the flow passage is fixed, the turbine's rotational speed is also a true representation of the volume of fluid flowing through the flowmeter. The rotation of the turbine rotor generates electrical pulses in the pickoff which is attached to the flowmeter housing in close proximity to the turning rotor. Each one of these pulses represent a discrete volume of fluid. The frequency or pulse repetition rate represents the flow rate and the accumulated pulse total represents the total volume measured.

3.1.2 The Standard Line Flowmeter consists of 3 basic assemblies (Refer to Figure 1).

3.1.3 The model number describes the characteristics of the meter (Refer to Tables 1 through 4). Meters provided for liquid applications are not interchangeable with meters provided for gas applications. All requests for information concerning a specific meter should contain the flowmeter model number and the flowmeter serial number.



1. Housing
2. Rotor & Support Assembly
3. Pickoff & Lock Nut Assembly

FIGURE 1

Flowmeter Basic Parts

3.2 MECHANICAL SPECIFICATIONS

Flow Range	See Tables 2, 3, and 4
Temperature	-430°F to +750°F determined by pickoff and bearing options selected
Viscosity	See Calibration Sheet
Back Pressure,	125% vapor pressure plus 2 x pressure drop across the meter
Pressure	Limited by end fittings

	LIQUID	GAS
Repeatability *	±0.05 of reading	±0.2% of reading
Linearity *	±.5% over normal	±1% of full scale
Pressure Drop	less than 10 psi for maximum normal flow rate.	less than 18 inches water for maximum normal flow rate.

Construction Materials:

Standard Housing/Internals	300 Series Stainless Steel
Standard Rotor	400 Series Stainless Steel

Optional Construction Materials:

Aluminum	Monel	17-4 PH
Hastelloy	Titanium	P.V.C.

Standard Bearing Options (See Table 1):

Liquid	440C Ball Bearings Tungsten Carbide Journal Graphite Journal
Gas	440C Ball Bearings (only) Graphite Journal (Consult Factory)

Standard End Fitting Options (See Figure 2):

MS (MS-33656) NPT WAFER FLANGE (ASA B16.5)
Other end fittings available. Consult Factory.

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* Except as noted in Tables 2, 3, and 4.

TABLE 1

BEARING APPLICATION GUIDE

BEARING TYPE	SERVICE	CORROSION RATING	TEMPERATURE RATING	COMMENTS
Ball (440C)	Liquid or Gas	Fair. Limiting factor - 440C Stainless.	-450° F to 300° F	Greatest reliability.
Graphite Journal[1]	Liquid, limited gas and steam service[2]	Good to Excellent	Up to 500° F	Epoxy impregnated graphite. Temperature rating limited by impregnant.
Carbide Journal[1]	Liquid	Good. Limiting factor - Tungsten Carbide.	Up to 1200° F[3]	Excellent wear resistance.
Ceramic[1] [2] Journal	Liquid	Excellent	Up to 1200° F[3]	Excellent wear resistance.
Polymer[1] [2] Journal	Liquid. Limited Gas Service.	Excellent	Up to 200° F	Limited usage because of wear and temperature limitations.

[1] Increased bearing friction limits low end of extended flow range.

[2] Consult Engineering for specific application.

[3] Temperature rating limited by pickoff availability.

TABLE 2

LIQUID SERVICE - BALL BEARING

MODEL	STD RANGE 10:1 (GPM) RF & MAG PICKOFF	EXTENDED RANGE (GPM) [2] RF PICKOFF	EXTENDED RANGE (GPM) [2] MAG PICKOFF	NOMINAL [1] K FACTOR (PULSE/ GALLON)	MAX. [1] FREQ (HZ)
FT4-8	.25 - 2.5	.03 - 3	.06 - 3	48000	2000
FT6-8	.5 - 5	.05 - 5	.1 - 5	25000	2100
FT8-8	.75 - 7.5	.08 - 8	.16 - 8	16000	2000
FT-08	1 - 10	.1 - 10	.2 - 10	12000	2000
FT-10	1.25 - 12.5	.15 - 15	.3 - 15	9600	2000
FT-12	2 - 20	.25 - 25	.5 - 25	6000	2000
FT-16	5 - 50	.6 - 60	1 - 60	2400	2000
FT-20	9 - 90	1 - 100	1 - 100	1300	1950
FT-24	15 - 150	1.6 - 160	1.6 - 160	600	1500
FT-32	22 - 225	2.5 - 250	2.5 - 250	350	1300

REPEATABILITY [1] = $\pm$ .05%
LINEARITY [1] = $\pm$ .5% OF READING

[1] BASED ON NORMAL 10:1 RANGE
[2] VOLTAGE OUTPUT WILL BE BELOW 30 MV P-P AT LOW FLOW RATE

TABLE 3

LIQUID SERVICE - JOURNAL BEARING

MODEL	STD RANGE 10:1 (GPM) RF & MAG PICKOFF	EXTENDED RANGE (GPM) [4] RF PICKOFF	EXTENDED RANGE (GPM) [4] MAG PICKOFF	NOMINAL [1] K FACTOR (PULSE/ GALLON)	MAX. [1] FREQ (HZ)
FT4-8 [2]	.25 - 2.5	.1 - 3	.12 - 3	48000	2000
FT6-8 [3]	.5 - 5	.15 - 5	.2 - 5	25000	2100
FT8-8	.75 - 7.5	.2 - 8	.25 - 8	16000	2000
FT-08	1 - 10	.25 - 10	.30 - 10	12000	2000
FT-10	1.25 - 12.5	.30 - 15	.4 - 15	9600	2000
FT-12	2 - 20	.5 - 25	.5 - 25	6000	2000
FT-16	5 - 50	1 - 60	1 - 60	2400	2000
FT-20	9 - 90	1 - 100	1 - 100	1300	1950
FT-24	15 - 150	1.6 - 160	1.6 - 160	600	1500
FT-32	22 - 225	2.5 - 250	2.5 - 250	350	1300

REPEATABILITY [1] = ± .1% FOR FT-12 AND SMALLER
± .05% FOR FT-16 AND LARGER

LINEARITY [1] = ± .5% OF READING EXCEPT AS NOTED. VALUES ARE VALID FOR VISCOSITIES OF 3 CENTISTOKES OR LESS.

1 BASED ON NORMAL 10:1 RANGE
2 LINEARITY IS ±2% OF READING
3 LINEARITY IS ±.75% WHEN HIGH TEMPERATURE MAGNETIC PICKOFF IS USED.
4 VOLTAGE OUTPUT WILL BE BELOW 30 MV P-P AT LOW FLOW RATE.

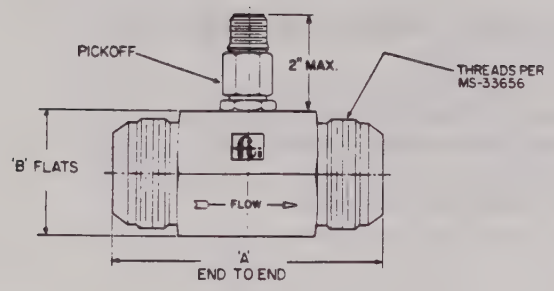
TABLE 4

GAS SERVICE - BALL BEARING

MODEL	STD RANGE 10:1 (ACFM) RF & MAG PICKOFF	EXTENDED RANGE (ACFM) RF PICKOFF	EXTENDED RANGE (ACFM) MAG PICKOFF [4]	NOMINAL [1] K FACTOR (PULSE/ CU FT)	MAX [1] FREQ (HZ)
FT2-8	0.1 - 1.0 [2]	.08 - 1.25	N/A	93000	1550
FT4-8	0.25 - 2.5 [3]	0.2 - 3.0	N/A	55000	2300
FT6-8	0.5 - 5.0	0.25 - 5.0	0.4 - 5.0	24000	2000
FT8-8	0.75 - 7.5	0.4 - 8.0	0.5 - 8.0	16000	2000
FT-08	1.0 - 10	0.5 - 10	0.75 - 10	12000	2000
FT-10	1.25 - 12.5	0.6 - 15	1.0 - 15	9600	2000
FT-12	2 - 20	1.0 - 25	1.5 - 25	6000	2000
FT-16	5 - 50	1.5 - 60	2.5 - 60	2400	2000
FT-20	9 - 90	2.5 - 100	5 - 100	1300	1950
FT-24	15 - 150	4 - 160	6 - 160	600	1500
FT-32	22 - 225	5 - 250	8 - 250	350	1300

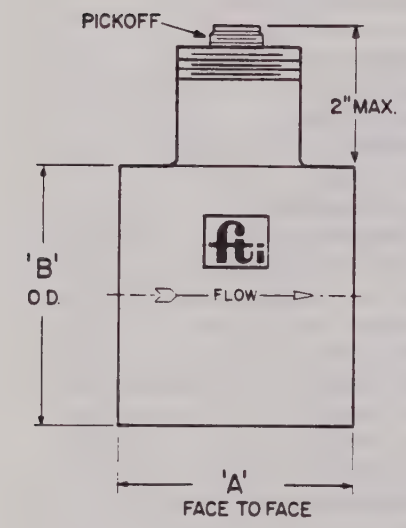
REPEATABILITY [1] = $\pm$.1%
LINEARITY [1] = $\pm$1.0% OF FULL SCALE

[1] BASED ON NORMAL 10:1 RANGE
[2] MAG PICKOFF NOT AVAILABLE
[3] MAG PICKOFF RANGE IS 0.35 - 2.5 ACFM
[4] VOLTAGE OUTPUT WILL BE BELOW 30 MV P-P AT LOW FLOW RATE



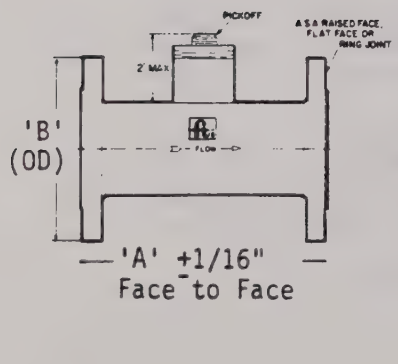
MS (MS-33656) OR NPT - STANDARD LINE

MODEL NO. PREFIX	NOMINAL END FITTING (INCH)	A	B
FT-2-8 FT-4-8 FT-6-8 FT-8-8 FT-8	1/2"	2.45"	1.0"
FT-10	5/8" (MS) 3/4" (NPT)	2.72"	1.31"
FT-12	3/4"	3.25"	1.38"
FT-16	1"	3.56"	1.63"
FT-20	1 1/4"	4.06"	1.88"
FT-24	1 1/2"	4.59"	2.13"
FT-32	2"	6.06"	2.75"



WAFER - STANDARD LINE

MODEL NO. PREFIX	NOMINAL END FITTING (INCH)	A	B
FT-2-8 FT-4-8 FT-6-8 FT-8-8 FT-8	1/2"	1.88"	1.38"
FT-10 FT-12	3/4"	1.94"	1.69"
FT-16	1"	2.50"	2.0"
FT-20	1 1/4"	2.50"	2.50"
FT-24	1 1/2"	2.50"	2.88"
FT-32	2"	3.0"	3.63"



FLANGED (ASA B16.5) STANDARD LINE

MODEL NO. PREFIX	NOMINAL END FITTING (INCH)	150# A	150# B	300# A	300# B	600# A	600# B	900# A	900# B	1500# A	1500# B	2500# A	2500# B
FT-2-8 FT-4-8 FT-6-8 FT-8-8 FT-8	1/2"	5.0	3.5	5.0	3.75	5.0	3.75	7.0	4.75	7.0	4.75	7.0	5.25
FT-10 FT-12	3/4"	5.5	3.88	5.5	4.63	5.5	4.63	7.0	5.13	7.0	5.13	7.0	5.5
FT-16	1"	5.5	4.25	5.5	4.88	5.5	4.88	8.0	5.88	8.0	5.88	8.0	6.25
FT-20	1 1/4"	6.0	4.63	6.0	5.25	6.0	5.25	8.0	6.25	8.0	6.25	8.0	7.25
FT-24	1 1/2"	6.0	5.0	6.0	6.13	6.0	6.13	9.0	7.0	9.0	7.0	9.0	8.0
FT-32	2"	6.5	6.0	6.5	6.5	6.5	6.5	9.0	8.5	9.0	8.5	9.0	9.25

Figure 2. Dimensions

3.3 ELECTRICAL SPECIFICATIONS:

Pickoffs: (See Table 5)	Magnetic Inductance, Magnetic Reluctance, Modulated Carrier (RF)
Options:	High Temperature (See Table 5) Explosion Proof (Consult Factory)
Connections:	MS, 2 pin (MS-3102-A-10SL-4P) 2 wire pigtails

TABLE 5

PICKOFF CHARACTERISTICS

TYPE OF PICKOFF	PICKOFF RESISTANCE	PICKOFF OUTPUT LEVEL	FREQUENCY RANGE
Magnetic (Inductive or Reluctance) 450°F Magnetic, High Temperature (Reluctance) 750°F	2000 to 3000 ohms depending upon the ambient temperature and the model number 100 to 200 ohm depending on the ambient temperature and the model.	Average 30 mV peak-to-peak for frequencies at lowest flow rate within normal 10:1 range	10 to 10 KHz depending upon size and calibration of the flowmeter. Refer to the calibration sheet that accompanies the flow meter.
Modulated Carrier (with FTI RF Amplifier)[1] 400°F	10 to 16 ohms	No output unless connected to a CA03 amplifier. A 10 volt pulse at the flowmeter frequency when the amplifier is connected and operating.	0.5 to 3500 Hz depending upon size and calibration of the flow meter. Refer to calibration data sheet.
Modulated Carrier High Temperature (with FTI RF Amplifier)[4] 800°F	3 to 5 ohms		
Water Cooled High Temperature[4] 1200°F with coolant	10 to 16 ohms	No output unless connected to a CA03 amplifier. A 10 volt pulse at the flowmeter frequency when the amplifier is connected and operating.	0.5 to 3500 Hz depending upon size and calibration of the flow meter. Refer to calibration data sheet.

[1] Electronics must be protected from excessive heat.

4.0 INSTALLATION OF THE STANDARD LINE FLOWMETER

4.1 INSPECTION UPON RECEIPT

4.1.1 The flowmeter should be unpacked carefully and inspected to verify that no damage occurred during shipment. Make certain that the internal parts are clean and free from packing materials or debris. The rotor should rotate freely.

> **CAUTION**
>
> The flowmeter is a precision instrument and may be damaged if a high pressure air hose is used for cleaning the flowmeter or for checking the rotation of the rotor.

4.2 MECHANICAL CONNECTIONS

4.2.1 The turbine flowmeter is sensitive to velocity profile disturbances in the flowing stream. Therefore, the line configuration should minimize or eliminate flow disturbances during calibration and use. The recommended line should be straight for a minimum of 10 diameters upstream and 5 diameters downstream (See Figure 3) and the upstream section should have straightening veins. The presence of major flow disturbance generators such as pumps, valves or elbows may require longer straight sections. If swirl is present in the line ahead of the flowmeter installation, a longer straight section may be required or flow straighteners may need to be installed.

4.2.1.1 Flow straightening should conform to industry standards and specifications, such as, ANSI/ISA RP31.1, API 2534/ANSI Z11.299, API RP550, etc.

4.2.1.2 Piping and system components should be arrranged to minimize pulsations entering the turbine meter. Pulsations may cause the meter to read high, and excessive pulsations may cause permanent bearing damage. Pulsations should be kept below 10% of the current flow rate at the meter location.

4.2.1.3 All flow lines in the meter system should be purged prior to installation of the meter. This will remove pipe dope, metal shavings, slag and debris which may damage the turbine meter.

4.2.1.4 Control valves should be located downstream from the turbine meter. System start-ups with upstream control valves in an unfilled system can result in a slug of liquid impacting on the meter, causing damage and a change in calibration.

CAUTION

Pressure should be increased gradually at start up to avoid possible damage by over-speeding the rotor. Refer to the section of this manual entitled, "Over Range" for specific start-up instructions.

The turbine flowmeter should be installed in accordance with the flow directional indications marked on the housing. A 3-valve bypass manifold installed around the meter as shown in Figure 3 allows purging the line while the meter is in place as well as repair of the meter while continuing the flow. Piping connections to the meter housing should be supported to prevent excessive stress on the meter body. The turbine meter should not be subjected to excessive vibrations which might affect performance and cause bearing damage.

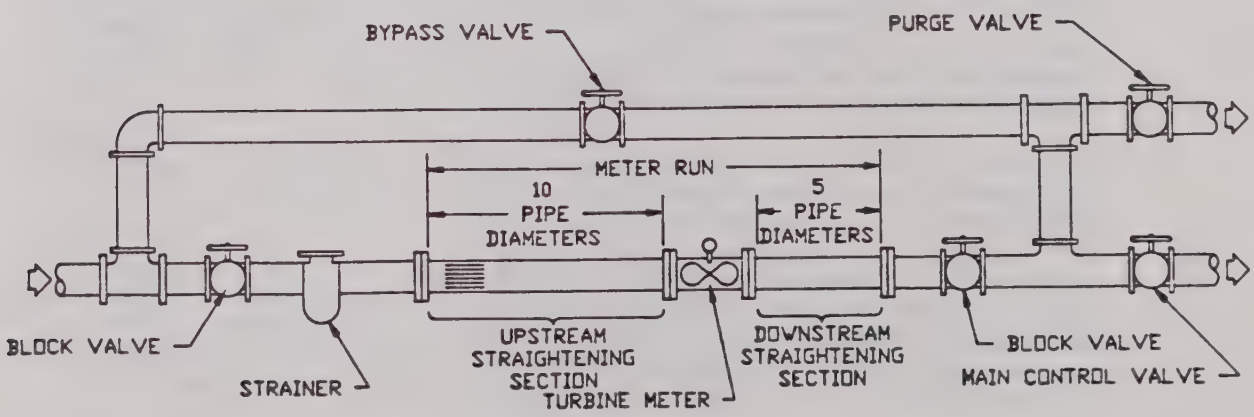


Figure 3. 3-Valve Bypass Manifold Pipe Schematic

NOTICE

FOR LIQUID FLOWMETERS, IT IS STRONGLY RECOMMENDED THAT THE FLOWMETER IS INSTALLED SO THAT IT REMAINS FULL OF FLUID WHEN THE FLOW CEASES. WHEN THE FLOW METER IS LEFT INSTALLED IN A LINE THAT IS TEMPORARILY OUT OF SERVICE AND HAS BEEN PARTIALLY OR FULLY DRAINED, SEVERE BEARING CORROSION MAY OCCUR. THE TYPE AND CORROSIVENESS OF THE FLUID BEING METERED, THE TYPE OF BEARING USED IN THE FLOWMETER, AND THE LENGTH OF TIME THE LINE WILL BE OUT OF SERVICE, ARE FACTORS WHICH MAY AFFECT THE LIFE AND OPERATION OF THE FLOWMETERS. IF IT IS ECONOMICALLY FEASIBLE AND CONDITIONS PERMIT, THE FLOWMETER SHOULD BE REMOVED, CLEANED AND STORED, WHEN THERE IS ANY DOUBT ABOUT THE FLUID LEVEL IN THE LINE DURING THESE OUT-OF-SERVICE PERIODS.

4.2.1.5 The attitude of the turbine flowmeter will influence the nature of the load on the rotor bearings, and thus, the performance of the meter at low flow rates. A turbine meter should be installed in the same attitude in which it was calibrated. Standard calibration attitude is with the meter axis horizontal and the pickoff vertical.

4.2.1.6 When particles are present in the fluid, a filter should be installed upstream of the flowmeter. For 1/2 inch diameter flowmeters, a 10 micron nominal filter should be used; for 3/4 inch and 1 inch flowmeters, a 20 micron nominal filter should be installed; for flowmeters 1-1/2 inch in diameter or larger, a 50 micron filter is recommended.

4.2.1.7 The following table indicates the recommended torques in foot-pounds for tightening MS-33656 flared-tube end fittings:

TABLE 6
RECOMMENDED TORQUES

SIZE	ALUMINUM TUBING		STEEL TUBING	
	MIN.	MAX.	MIN.	MAX.
1/2"	12	20	27	40
3/4"	25	40	75	85
1"	40	60	100	120
1-1/2"	50	75	---	---

4.3 ELECTRICAL CONNECTIONS

The standard pickoff connector is an AN two-contact type MS3102A-10SL-4P with the mating connector. Pigtail configurations are also available.

4.3.1 The connecting cable between the flowmeter and the electronic display instrument should be two conductor, 22 AWG, shielded, twisted cable with vinyl jacket (Belden 8761 or equivalent). The cable should not be installed in a conduit or tray containing power lines, nor close to strong electromagnetic sources such as electric lines, electric motors, transformers, welding machines, or high voltage lines. These sources may induce transient electrical noise in the coil and cause false pulse signals.

4.3.2 The shield of the cable is to be grounded at only one point in accordance with the instruction of the display instrument. FTI display instruments specify where the shield is to be grounded.

4.4 PICKOFF INSTALLATION

4.4.1 Pickoffs should bottom in the well of the flowmeter housing but should only be finger tightened to approximately 4 in-lb (4500 gm-cm max) to prevent distortion of the coil housing. The pickoff is secured in position by tightening the lock nut to approximately 25 in-lb (30000 gm-cm). Pickoff is removed by loosening the hex lock nut and unscrewing pickoff from the housing.

4.4.2 Flowmeters, with explosion proof housings, have the pickoff installed inside a short section of conduit pipe (spud) that is welded to the housing. Since the spud is longer than the pickoff, the pickoff cannot be finger tightened directly, and an alternate method must be used to install the pickoff. A modified 11/16 inch deep socket is required to screw the pickoff into the housing, and a modified 13/16 inch deep socket is used to tighten lock nut.

4.4.3 To install or remove a pickoff in the field when the pickoff is installed in conduit pipe, the following procedure is recommended:

1. Modify a standard 11/16 inch deep socket with an elongated 3/8 inch hole as shown in Figure 4. This socket will fit pickoff and allow easy feed through of the lead terminals without damaging the leads.

2. Modify a standard 13/16 inch deep socket with an elongated hole (See Figure 4). Cut the outside diameter of the socket to 1.015 inches to permit the socket to tighten lock nut inside conduit without damaging leads.

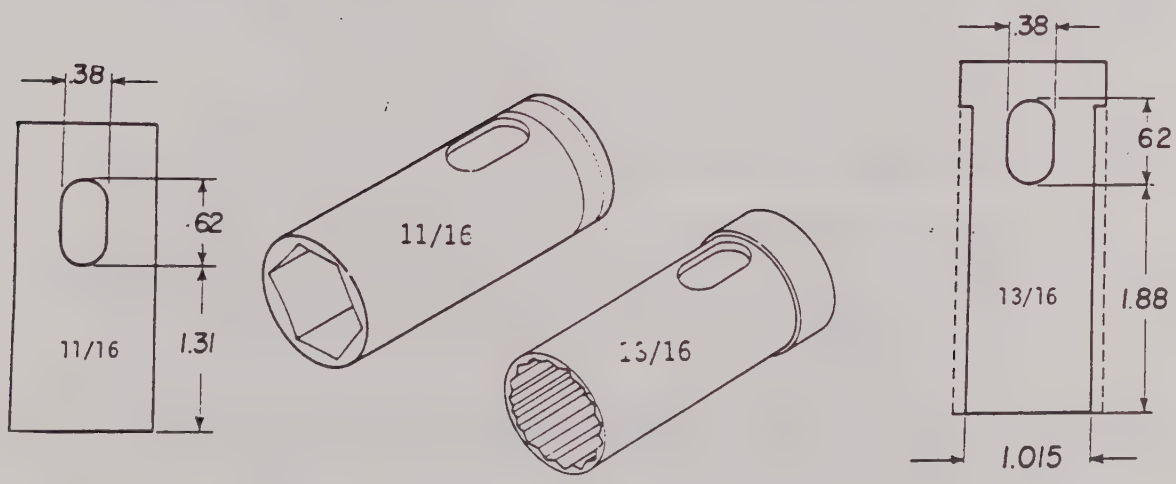


Figure 4. Pickoff Installation Sockets

4.4.4 An electronic signal conditioning circuit is required to convert the frequency output of the flowmeter into a visual presentation on a display or to provide process control signals. FTI manufactures a complete line of flowmeter electronic packages. A typical pickoff connection to the electronic readout equipment is shown in Figure 5.

4.4.5 The Magnetic pickoff output is a low level signal that ranges from 10 mV to several volts peak-to-peak. A pulse amplifier (signal conditioner) is needed to convert the pickoff low level signal to a 10 V peak (reference to ground) pulse signal suitable for process instrumentation.

4.4.6 The Modulated Carrier (RF) pickoff must be installed with an appropriate amplifier (Consult factory). The amplifier is needed to convert the modulated carrier signal to a 10 V peak (reference to ground) pulse signal suitable for process instrumentation.

4.4.7 Figure 6 shows a pickoff connection diagram. The following rules must be observed for proper operation:

1. Do not mount the pickoff close to electrical equipment (motors, relays, etc.).

2. Use a twisted and shielded cable (Belden 8761 or equivalent) for the pickoff/amplifier connection.

3. Mount the amplifier as close as possible to the pickoff. For Magnetic pickoffs, up to 1000 feet of Belden 8761 (or equivalent) is the maximum cable length in an electrically noise free environment. For Modulated Carrier (RF) pickoffs, cable length may not exceed 30 feet.

4. The conduit for the pickoff cable must not be shared with other services (cables).

5. A #14 AWG (or larger diameter) ground wire connected from the amplifier ground to the pickoff body or pipe may reduce electrical noise.

6. Earth ground attached to the amplifier ground may reduce the noise.

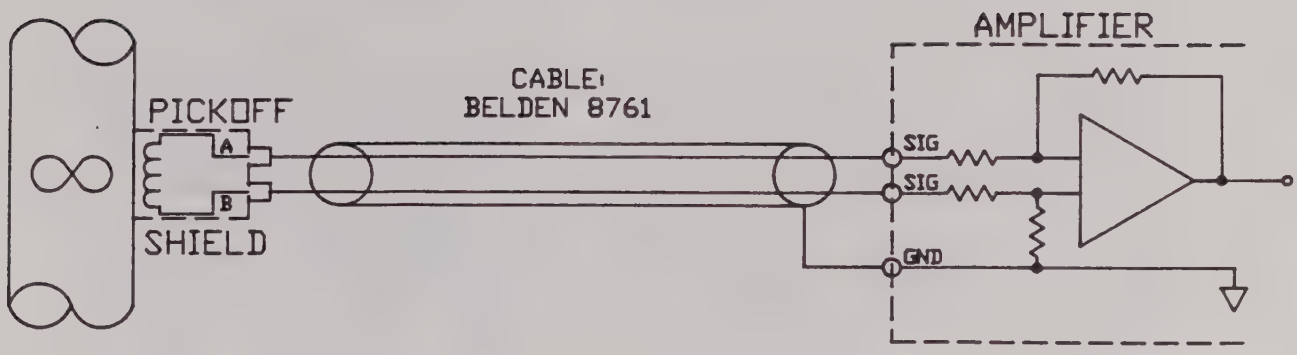


FIGURE 5. PICKOFF CONNECTION TO ELECTRONICS

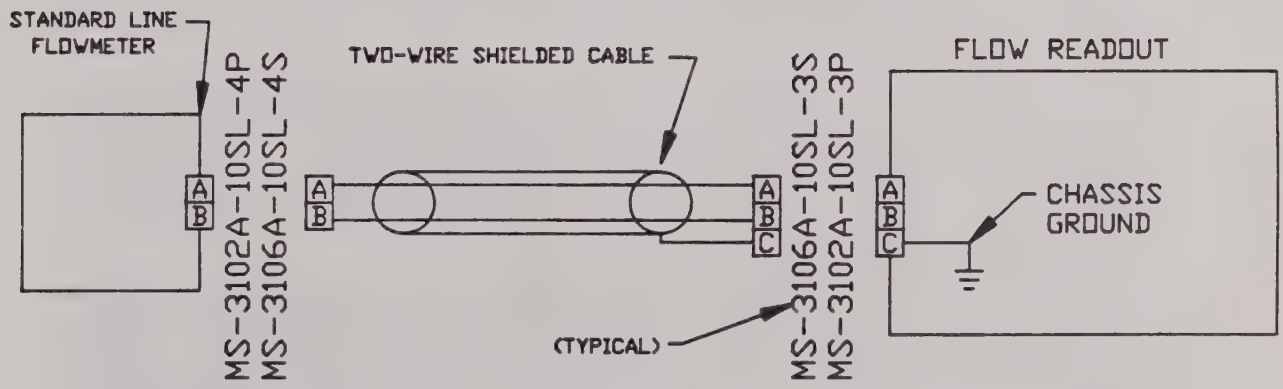


FIGURE 6. MAGNETIC PICKOFF CONNECTIONS

5.0 OPERATION

5.1 OVER RANGE

Once a turbine meter has been installed, the greatest hazard is over ranging of the meter. In general, turbine meters remain quite linear when they are over ranged, and it may not be immediately apparent that the instrument is being misused. However, the pressure drop will become excessive, and overspeeding of the bearings will cause permanent damage. Bearings may be damaged by excessive downstream thrust load. FTI's specifications should be consulted for over range capability of the instrument. During operation and especially during system start-up, 50% over range is normal over the extended top end of ball bearing and journal bearing flowmeters for brief periods of time is allowable. For jewel bearings, 25% over range is normal. Output frequency of the meter should be monitored to insure frequency corresponding to the maximum over range is not exceeded. The probability of an overspeed condition for liquid flowmeter usually occurs during system start up when there is still air in the lines. Air should be bled carefully from lines before high flow range is established.

5.2 UNDER RANGE

When used below the minimum specified range, turbine meters may become very non-linear. The repeatability of the meter may also be poor due to bearing drag.

5.3 BIDIRECTIONAL FLOWMETERS

5.3.1 Turbine flowmeters can be configured to measure flow in both directions and provide direction sensing capability. This is accomplished by adding a second pickoff, located with respect to the first pickoff in such a way as to achieve a 90° phase shift. The location of the pickoffs is determined by the number of blades on the rotor.

5.3.2 Once the pickoffs have been spaced properly and the correct rotor has been selected, the unit need only be connected to a bidirectional flow rate indicator such as FTI's FR-10 module used in various FTI electronic equipment such as the 50 Series and the FC81. Such an indicator incorporates a phase detection circuit in conjunction with the usual frequency-to-analog conversion circuitry. It will display a positive or negative flow indication depending upon which pickoff has the leading output. It can also be furnished with a positive or negative voltage output and dual current outputs. One will be zero while the other produces an analog output. The direction of flow is determined by which of the dual outputs is in the zero state.

5.4 TURBINE FLOWMETER LIQUID CHARACTERISTICS

When measuring the flow of a liquid, a turbine meter generates an electrical pulse for each discrete volume of fluid passing through it. The frequency or pulse repetition rate of the electrical signal that is generated is proportional to the flow rate of the liquid, provided that the flow rate is within the design range of the flowmeter.

5.4.1 The relationship between the number of pulses produced by the flowmeter and the volume of liquid passing through it is called the meter calibration factor. This is usually termed the "K-factor" in technical shorthand.

5.4.1.1 K-factor is a unit normally expressed in terms of pulses per unit volume such as pulses per gallon, pulses per liter, or pulses per barrel, for example.

5.4.1.2 Each individual flowmeter has its own K-factor. This is determined by calibrating the flowmeter, where a known volume of liquid is passed through the flowmeter in a known period of time. At FTI, this calibration is accomplished with Flow Calibrators traceable to the National Institute of Standards and Technology (NIST), formerly NBS.

5.4.2 The accuracy of the flowmeter is the degree to which the pulses represent the true volume of liquid passing through the flowmeter over a specified flow rate range. Flow rate is a derived standard since one can obtain traceability to standards, for volume or for time, but not for volume-per-unit time.

5.4.3 The repeatability of a flowmeter is its ability to reproduce a given signal output or K-factor under identical conditions of flow rate, temperature, viscosity, pressure, and other fluid parameters.

5.4.4 The flowmeter's linearity is the variation experienced from a constant K-factor over a specified flow range. Ideally, a flowmeter should have a constant K-factor over its entire design flow rate range. In the real world, the K-factor changes slightly with flow rate, and the flowmeter's linearity specification describes this deviation from the ideal flat curve.

5.4.4.1 A level or flat K curve generally happens when the kinematic viscosity of the fluid is less than 3.0 centistokes.

5.4.5 If the flowmeter is used with liquids having viscosities greater than 3.0 centistokes, the K-factor will change. This effect is sometimes referred to as "viscosity shift". Note that the higher viscosity of the fluid, the greater the viscosity shift effect.

5.4.5.1 It is possible to compensate for viscosity shift to some extent by multiple viscosity calibrations because it is often desirable to use a flowmeter with liquids that may have widely different viscosities. For this purpose, FTI can provide a customer with a "Universal Viscosity Curve". One can determine the K-factor of a flowmeter when used with liquids of different viscosities. (Note: Bearing drag may cause meter to deviate from Universal Viscosity Curve at low range.)

5.4.5.2 The data needed to plot a Universal Viscosity Curve is obtained from a number of "ten-point" calibrations of the flowmeter using fluids of several viscosities. When plotted on a K-factor versus Hz/v (where Hz = frequency in Hz and v = kinematic viscosity in centistokes) curve, the data points will overlap to form a smooth curve.

5.4.5.3 Using a Universal Viscosity Curve, the performance of a given flowmeter can be determined for an output frequency (Hz) or any viscosity (V) if the Hz/V valve is within the range of data used to generate the curve. One merely finds the Hz/V value and reads the corresponding K-factor directly from the Universal Viscosity Curve.

5.4.5.4 The correlation of data obtained from calibration and from the data taken from a Universal Viscosity Curve, will be within $\pm$0.5% and can approach $\pm$ 0.25% when using such liquids as oil or hydrocarbons.

5.4.6 The data sheet supplied with this flowmeter gives the actual pulses per gallon measured at various flow rates during the calibration operation.

5.4.6.1 The pulses generated by the flowmeter, the GPM flow rates, and the "pulses per gallon" are related as follows:

$$\text{FLOW in GPM} = \frac{\text{Pulses per second (or frequency in Hz)} \times 60}{\text{Pulses per gallon}}$$

$$\text{Pulses per second (or frequency in Hz)} = \frac{\text{GPM} \times \text{Pulses per gallon}}{60}$$

MASS FLOW in pounds per hour (PPH) is a function of the specific gravity:

$$\text{PPH} = \frac{\text{Pulses per second (or frequency in Hz)} \times 3600 \times \text{S.G.} \times 8.345}{\text{Pulses per gallon}}$$

For reference, the approximate relationship between GPM and PPH is:

$$\text{PPH} = \text{GPM} \times 500 \times \text{S.G.} \quad \text{or} \quad \text{GPM} = \frac{\text{PPH}}{500 \times \text{S.G.}}$$

5.5 TURBINE FLOWMETER GAS CHARACTERISTICS

When measuring liquids, a flowmeter's output is readily related to an absolute standard because the volume of the liquid is essentially independent of its pressure i.e., the liquid is considered to be incompressible in the flow regimes normally covered by turbine flowmeters. This simple approach cannot be taken when a turbine flowmeter measures the flow of a gas. A gas is, by definition, compressible. It changes its volume with changes in both its temperature and its pressure in accordance with the relationships established by Boyle's Law and Charles' Law.

5.5.1 In order for the actual volume of gas measured by the turbine flowmeter to have useful technical meaning, it must be related to an absolute standard: an equivalent volume of gas at a mutually agreed upon standard of temperature and pressure. The "actual" measured volume of gas must be compared against its equivalent "standard" volume of gas.

5.5.1.1 The standard conditions of pressure and temperature that are used in the United States of America are:

Pressure: 14.7 pounds per square inch absolute (psia)

Temperature: 520 degrees Rankine (60 degrees Fahrenheit)

For proper conversion, an absolute temperature scale must be used.

5.5.1.2 In the metric SI system, these standards are cubic meters per second at 0°C and 1 atmosphere (760 mm of Hg) pressure.

5.5.2 The actual flow rate of gas passing through the turbine flowmeter is expressed in terms of actual cubic feet per minute, ACFM, in the English system. In the metric (SI) system, the unit is cubic meters per second.

5.5.2.1 The equivalent flow rate of the gas at standard conditions of temperature and pressure set forth is in terms of standard cubic feet per minute, SCFM, or standard cubic meters per second, SCMS.

5.5.3 To convert from ACFM to SCFM, we must assume that the gas obeys the Perfect Gas Law.

5.5.3.1 The following equation is used to convert the actual, measured volume flow rate in ACFM to equivalent of standard conditions of SCFM:

$$Q_s = Q_a \times \frac{P_a}{P_s} \times \frac{T_s}{T_a}$$

where:

Q_s = gas flow rate in SCFM (or m^3/sec)

Q_a = gas flow rate as measured in ACFM (or m^3/sec)

P_a = measured gas pressure in the flowmeter in psia (or kg/cm^2)

P_s = standard pressure = 14.7 psia = 1.0333 kg/cm^2

T_s = standard temperature = 520°R = 273.2°K

The "short form" of this equation, created by gathering an combining the terms for English system units, can be written as:

$$Q_s = Q_a \times 35.37 \times \frac{P_a}{T_a}$$

$$= 35.37 \frac{Q_a P_a}{T_a}$$

5.5.3.2 The pressure and temperature measurements made to obtain the data for conversion should be taken immediately downstream of the turbine flowmeter.

6.0 MAINTENANCE

6.1 PERIODIC MAINTENANCE

Maintenance of the Standard Line Flowmeter consists of periodic inspections to insure that the internal parts have not suffered any corrosion or incrustation by measuring fluid. Should the assembly be damaged, it should be returned to the factory for exchange or repair.

6.2 INSPECTION AND CLEANING

6.2.1 For inspection and cleaning of internal parts, the rotor and support assembly may be withdrawn from the housing. The rotor support assembly and the housing may be cleaned with appropriate solvent or alcohol. If the flowmeter is to be stored or out of service for an extended period, it should be dipped in a light rust proofing preservative or machine oil.

> **C A U T I O N**
>
> Service for some fluids may require special cleaning procedures before installation. Please consult fluid manufacturer and/or use industry accepted procedures.

6.2.2 One of the largest single sources of poor turbine meter performance is foreign material buildup on bearings whether they are journal type or ball type.

6.2.2.1 A majority of liquid measured by turbine meters contains impurities, which if allowed to remain within the flowmeter after use, would form hard or gelatinous residues. When these residues are deposited within the rotor bearing, freedom of rotation will be severely degraded.

6.2.2.2 It is recommended that whenever possible, the turbine meter be thoroughly flushed with an appropriate solvent immediately after use. The solvent should be chemically neutral, and highly volatile so that complete drying can take place soon after the flushing operation. Some appropriate solvents would be ethyl alcohol, freon, or stoddard solvent.

6.2.3 All turbine flowmeters include some type of bearing for supporting its rotor. The standard line flowmeter is normally equipped with ball bearings, but journal bearings fabricated of tungsten carbide, ceramic, epoxy impregnated graphite and other non-metallic materials are also available. If the bearings in the flowmeter become damaged or worn, the meter should be sent to the factory for bearing replacement. If this is not possible, a bearing replacement kit is available for some models. All bearings are not field replaceable. Consult the factory and describe the particular flowmeter before ordering a bearing replacement kit.

6.3 BEARING REPLACEMENT

6.3.1 Ball Bearing Replacement

Ball bearings may be replaced in the field by the customer, without significantly changing the flowmeter, provided the downstream orientation of the rotor is maintained. (Refer to the Illustrated Parts List)

6.3.1.1 The ball bearing replacement for the FT4-8 shall be accomplished in the following order (Refer to Figure 7):

1. Remove the retaining ring (2) from either end of the flowmeter housing.

2. Gently slide the flowmeter rotor support assembly out of the housing, being careful not to drop any of the internal parts as they clear the housing.

3. Remove the downstream support (6) and the cone (7A) from the shaft (7B). Note on the flanged meters there is an upstream and downstream spacer (8) between the support (6) and the retaining ring (2).

4. Note that the rotor (7C) is marked on the downstream side with two lines on the rotor hub.

5. Gently slide the rotor assembly from the shaft (7B).

6. Slide both bearings (10) and the bearing spacer (11) out of the rotor hub (7C).

7. Install the new retaining ring (9) in the rotor hub (7C) and slide the new bearing spacer (11) and the two new ball bearings (10) into the rotor hub (7C).

8. Reverse Steps 1 through 5 for re-assembly. Insure that the flow direction arrow on the internals match the flow direction arrow on the housing when the internals are reinstalled. Insure the rotor (7C) is properly oriented with markings on the downstream side.

6.3.1.2 Ball bearing replacement for FT6-8 through FT-24 shall be accomplished in the following order (Refer to Figures 8 and 9):

1. Remove the retaining ring (2) from either end of the flowmeter housing.

2. Gently slide the flowmeter rotor support assembly out of the housing, being careful not to drop any of the internal parts as they clear the housing.

3. Remove the downstream support (6) and cone (7A) from the shaft (7B). Note on the flanged meters there is an upstream and downstream spacer (8) between the support (6) and the retaining ring (2).

4. Note that the rotor (7C) is marked on the downstream side with two lines on the rotor hub.

5. Gently slide the rotor assembly from the shaft.

6. Remove the retaining ring (9) from the marked side of the rotor (7C) and slide both bearings (10) and bearing spacer (11) out of the rotor hub. (No bearing spacers (11) on .370 through .440 bore meters.)

7. Install the two new ball bearings (10), spacer (11) as required, and retaining ring (9) into rotor hub (7C).

8. Reverse Steps 1 through 5 for re-assembly. Insure that the flow direction arrow on the internals match the flow direction arrow on the housing when the internals are reinstalled.

Insure the rotor (7C) is properly oriented with markings on the downstream side.

6.3.1.3 Ball Bearing Replacement for FT-32 shall be accomplished as follows (Refer to Figure 10):

1. Remove the retaining ring (2) from either end of the flowmeter housing.

2. Gently slide the complete set of internals out of the housing, being careful not to drop any of the internal parts as they clear the housing.

3. Remove one of the self-locking nuts (13) from the end of the support (6).

4. Remove support (6), cone (7A), and spacer (12) from the shaft (7B).

5. Note that the rotor (7C) is marked on the downstream side with two lines on the rotor hub.

6. Gently slide the rotor assembly and sleeve (14) from the shaft (7B).

7. Remove the retaining ring (9) from the marked side of the rotor (7C) and slide both bearings (10) and bearing spacer (11) out of the rotor hub.

8. Install the two new ball bearings (10), spacer (11) and retaining ring (9) into the rotor hub.

9. Reverse Steps 1 through 6 for re-assembly. Insure that the flow direction arrow on the internals matches the flow direction arrow on the housing when the internals are reinstalled.

Insure the rotor (7C) is properly oriented with markings on the downstream side.

6.3.2 Journal Bearing Replacement

6.3.2.1 FTI has bearing replacement kits available for turbine flowmeters equipped with journal bearings. The use of a replacement kit will allow the customer to repair the flowmeter in the field.

NOTE

The flowmeter will require recalibration after installation of a new journal bearing kit.

6.3.2.2 Replacement kits are ordered by specifying the flowmeter model number and serial number.

6.3.2.3 For epoxy impregnated graphite and non-metallic (Teflon, Torlon, etc.) journal bearings, the replacement kit consists of a journal bearing, rotor and shaft assembly (sleeve on FT-32) that replaces the existing rotor subassembly. The rotor, the journal bearing, and the shaft (sleeve on FT-32) are a factory matched set of components designed for a specific flowmeter.

NOTE

1/2 inch flanged meters may have support spacers between retaining rings and supports to properly position the rotor within the housing.

6.3.2.4 The replacement kit for tungsten carbide or ceramic journal bearings on the FT-24 and Smaller consists of a journal bearing, shaft (sleeve on FT-32), and rotor and the the upstream and downstream cones that have carbide thrust washers installed (No cones on FT-32), and are factory matched components.

6.3.2.4.1 Follow this procedure for replacing the graphite, rulon, torlon, etc. journal bearings on the FT-24 and Smaller (Refer to Figures 11, 12, and 13):

1. Remove the retaining ring (2) from the upstream end of the housing.

2. Gently slide the flowmeter rotor support assembly out of the housing, being careful not to drop any of the internal parts as they clear the housing.

3. Remove the upstream support (6) and cone assembly (15A) from the shaft (15B). (This is a close tolerance fit and may require twisting the supports to free the shaft.)

4. Remove shaft (15B) and rotor assembly (15C) from the downstream support (6) and cone assembly (15A).

5. Install the new rotor (15C) and journal bearing assembly (15D) in the downstream support (6) and cone assembly (15A). Observe the downstream marking on the rotor. The flange of the journal bearing (red, black, or white) marks the downstream side of the rotor on the FT-16 and larger.

6. Install the upstream support (6) and cone assembly (15A) on the new rotor assembly.

7. Install the completed assembly into the flowmeter housing by inserting the downstream support in accordance with the flow direction arrow on the housing.

8. Install the upstream retaining ring (2) and check to make sure that the rotor (15C) rotates freely in the housing.

6.3.2.4.2 Follow this procedure for replacing the journal tungsten carbide or ceramic bearings on the FT-24 and Smaller (Refer to Figures 15 and 16):

1. Remove the retainer ring (2) from the upstream end of the housing.

2. Gently slide the flowmeter rotor support assembly out of the housing, being careful not to drop any of the internal parts as they clear the housing.

3. Remove both support (6) and cone assemblies (16A) from the shaft (16B). (This is a close tolerance fit and may require twisting the supports to free the shaft.) (The cone will be replaced with new assemblies.)

4. Install the new cone assemblies (16A) into both supports (6).

5. Install the new rotor (16C) and journal bearing assembly (16D) in the downstream support (6) and cone assemblies (16A).

6. Install the new upstream support (6) and cone assemblies (16A) on the new rotor assembly (16C).

7. Install the completed assembly into the flowmeter housing by inserting the downstream support in accordance with the flow direction arrow on the housing.

8. Install the upstream retaining ring (2) and check to make sure that the rotor (16C) rotates freely in the housing.

6.3.2.5 Follow this procedure for replacement of the graphite, rulon, torlon, etc. journal bearings for FT-32 (Refer to Figure 14):

1. Remove the retaining ring (2) from the upstream end of the housing.

2. Gently slide the complete set of internals out of the housing, being careful not to drop any of the internal parts as they clear the housing.

3. Remove one of the self-locking nuts (13) from the end of the support (6).

4. Remove the upstream support (6), spacer (12) and cone (15A) from the shaft (15B).

5. Remove the sleeve (14) and rotor assembly (15C) from the downstream support (6) and cone (15A).

6. Install the new rotor (15C) and journal bearing assembly (15D) in the downstream support (6) and cone assembly (15A). Observe the downstream marking on the rotor. The flange of the journal bearing (15D) (red, black, or white) marks the downstream side of the rotor.

7. Install the upstream support (6), spacer (12), and cone assembly (15A) on new rotor assembly (15C).

8. Tighten the self-locking nuts (13) on the end of the supports (6).

9. Install the completed assembly into the flowmeter housing by inserting the downstream support in accordance with the flow direction arrow on the housing.

10. Install the upstream retaining ring (2) and check to make sure that the rotor (15C) rotates freely in the housing.

6.3.2.5.1 Follow this procedure for replacement of the tungsten carbide or ceramic journal bearings for FT-32 (Refer to Figure 17):

1. Remove the retaining ring (2) from the upstream end of the housing.

2. Gently slide the complete set of internals out of the housing, being careful not to drop any of the internal parts as they clear the housing.

3. Remove one of the self-locking nuts (13) from the end of the support (6).

4. Remove the upstream support (6), and cone (15A) from the shaft (16B).

5. Remove the sleeve (14), spacers (12) and rotor assembly (16C) from the downstream support (6) and cone (16A).

6. Install the new rotor (16C), spacers (12), sleeve (14) and journal bearing assembly (16D) in the downstream support (6) and cone assembly (16A). Observe the downstream marking on the rotor. Insure the groove on the spacers face the bearing.

7. Install the upstream support (6) and cone assembly (16A) on new rotor assembly (16C).

8. Tighten the self-locking nuts (13) on the end of the supports (6).

9. Install the completed assembly into the flowmeter housing by inserting the downstream support in accordance with the flow direction arrow on the housing.

10. Install the upstream retaining ring (2) and check to make sure that the rotor (16C) rotates freely in the housing.

7.0 TROUBLESHOOTING GUIDE

Turbine flowmeters are inherently reliable devices and many of the problems that occur during operation are the result of improper installation and/or maintenance.

In the following pages, a guide shows some of the common problems that occur during the use of turbine flowmeters.

Various causes are given for each problem including a description of the cause and the corrective action to be taken.

7.1 METER READS HIGH

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
Air in Line - Bubbles or Froth (Liquid Meters Only)	Line not full of fluid.	Check plumbing arrangement.
Cavitation (Liquid Meters Only)	Fluid vaporizes as it slips over rotor blades & liquifies beyond blades.	Check for insufficient back pressure.
Pulsations (Fluid Surges)	Pump or rotor actions.	Provide damping in system.
Viscosity Shift (Calibration Viscosity & Operative Viscosity are Different)	Operating fluid does not have the same viscosity as the fluid used to calibrate the flowmeter.	Recalibrate in proper fluid.
	OR	
	Temperature of the metered fluid differs from the temperature used for calibration.	Recalibrate for the operation temperature.
Invalid Calibration	Calibrated in wrong fluid.	Recalibrate in proper fluid.
	OR	
	Specifications for calibration not clear	Clarify specs and recalibrate.
Pressure Variations (Gas Meters Only)	Calibrated at atmosphere but run at high density due to high pressure.	Recalibrate at proper density.

METER READ HIGH (continued)

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
Improper Electrical Installation	Power and signal cables are run together.	Separate cables and check for noise signal of sufficient amplitude to be mistaken as a flowmeter signal.
	OR	
	Improper hook-up of cable shields.	Check for ground noise that can be mistaken as a flowmeter signal.
	OR	
	Voltage spikes on signals.	Check for transients and spikes that can be mistaken as a flowmeter signal.
	OR	
	Gain adjustment of magnetic input amplifier is set high.	Check to see if the input amplifier is amplifying noise signals or is oscillating.
Improper Mechanical Installation	Gasket intruding into flow stream.	Check to see if the gasket has shifted and is disturbing flow stream.
	OR	
	RF amplifier is installed in close proximity to the high temperature line.	Relocate the RF amplifier where the temperature of the fluid line does not affect its operation. An extension may be added between the flowmeter and the amplifier.
	OR	
	Insufficient filtering.	Check to see if foreign material has built up on rotor or supports.

METER READS HIGH (continued)

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
Deformed Flowmeter (Foreign Materials in Flowmeter)	Foreign materials have accumulated on flowmeter internals and act as accelerators.	Check for deposit build-up on rotor or supports.
	OR	
	Foreign materials in fluid have deformed internals.	Check supports and rotor blades for damage.
Improper Flow Straightening (Jetting)	Line input to the flowmeter is much smaller than the meter opening and the stream of input flow forces the meter to operate faster.	Check the input connections to the flowmeter.
Improper Flow Straightening (Swirl)	Turbulent flow of fluid created by valves, line geometry, and insufficient straightening sections.	Check the geometry of the line. Install flow straighteners.

7.2 METER READS LOW

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
Distorted Signals	Magnetized rotor (Hint: Error is some multiple of magnetized blades divided by number of rotor blades. NX = $\frac{1}{\#\ \text{OF Blades}}$).	Check for unequal signal in repeat pattern. Degauss rotor blades.
	OR	
	RF Amplifier to flowmeter mismatch	Check for electrical mismatch between RF circuit and the flowmeter.
Varying Signal Amplitude	Electronics does not detect some pulses.	Adjust amplifier gain.
	OR	
	Bent rotor blades (amplitude and width of signals may vary).	Check to see if the signals produced by the rotor blades are individual pulses. Replace rotor if pulses are not differentiated from each other.
Noise Pickup	Power and signal cables are run together	Check to see if large noise signal from motor or relay is preventing the detection of pulses.
	OR	
	AC signals override flowmeter signals and are detected as pulses.	Check for 60 Hz signals that attenuate or override flowmeter signals.

METER READS LOW (continued)

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
Weak Flowmeter Signal	Weak flowmeter signal is not detected by electronics.	Check for weak flowmeter signal that may not be detected above the noise level of the electronics.
Viscosity Shift	Operating fluid has a viscosity different then the fluid used for calibrating the flowmeter.	Recalibrate in proper fluid.
	OR	
	Temperature change has caused a viscosity shift of the operating fluid.	Recalibrate for the operating temperature.
Improper Flow Straightening (Swirl)	Turbulent flow of fluid created by valves, line geometry, and insufficient straightening sections.	Check the geometry of the line. Install flow straighteners.
Pulsation (Pump Actions)	Fluid surges (possible, but meter will usually read high).	Provide damping in the system.
Improper Electrical Installation	Loose pickoff.	Verify that the pickoff bottoms in the housing and secure locknut.
	OR	
	Improper hook-up of cable shield.	Check for ground loops that attenuate the signals into the noise level.

METER READS LOW (continued)

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
Improper Mechanical Installation	Fluid contamination.	Foreign material in bearings; clean bearings.
	OR	
	Meter install backwards.	Check to see if the flow direction arrow on the flowmeter is aligned with the direction of flow.
	OR	
	Internals installed backwards.	Verify meter is assembled properly.
	OR	
	Meter installed in different orientation than calibrated.	Check the data sheet to ascertain proper orientation for the flowmeter.
	OR	
	Filter is installed in the wrong place, or is the wrong size.	Check for deposit build-up on rotor and supports. Clean internals and flush the line.
	OR	
	Gasket intrudes into line and blocks flow.	Check to see if the gasket has shifted and disturbs the flow of fluid.
Calibration in Improper Fluid	Fluid viscosity is not the same as the viscosity of the fluid used for calibration.	Recalibrate in proper fluid.

METER READS LOW (continued)

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
Improper Flowmeter Assembly	Missing internals after installing bearing kit.	Install all parts within flowmeter.
Defective Bearings	Intermittent operation.	Clean or flush the system.
	OR	
	Frozen or locked.	Disassemble the flowmeter and clean the bearings.
	OR	
	Corroded or worn.	Replace bearings.
Pressure Variations (Gas Meters Only)	Calibrated at atmosphere but run at low pressure.	Recalibrate for low pressure.
Invalid Calibration (Associated Equipment)	Flowmeter is not mated to proper electronics.	Check data sheets and assemble system correctly.
Lack of Lubrication	Bearing misapplication.	Use proper bearing.

7.3 ZERO OUTPUT

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
RF Amplifier	Pickoff not connected or not installed properly.	Check the pickoff. The pickoff must be connected to the readout instrument and be bottomed in the flowmeter housing.
	OR	
	Impedance mismatch.	Check for an impedance mismatch between the RF amplifier and the readout instrument.
	OR	
	High temperature pickoff.	RF Amplifiers are temperature sensitive and require a high temperature pickoff for high temperature operation. Insure that the fluid temperature is not above the operational temperature range of the pickoff.
	OR	
	RF Amplifier electronics overheated.	Check that the RF amplifier is not placed in proximity of the flowmeter where the fluid temperature can affect RF amplifier operation.

ZERO OUTPUT (continued)

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
Electronic Malfunction	Pickoff is working but the electronic unit does not totalize or perform flow rate indication.	Troubleshoot the electronics.
Pickoff Defective or Improperly Installed	Open coil.	Perform resistance check on pickoff leads for 3 to 3000 ohms.
	OR	
	Broken leads.	Perform resistance check on pickoff leads for above readings.
	OR	
	Pickoff not bottomed in flowmeter housing.	Finger tighten the pickoff in the flowmeter housing and secure with locking nut.
Improper Wiring	Flowmeter and readout instrument are not connected.	Check the wiring to see that the system is interconnected.
	OR	
	Flowmeter and readout instrument are improperly connected.	Check the wiring to ensure that system is wired correctly between components. Check for connections to wrong terminals, units improperly grounded and loose connections.

ZERO OUTPUT (continued)

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
Improper Wiring (continued)	OR	
	Excessive distance from flowmeter to readout instrument.	Check the distance between components of the system. The maximum allowable distance between the pickoff and the amplifier is 1000 feet for magnetic amplifier and 100 feet for the RF amplifier.
	OR	
	Broken wires.	Check for signals at both ends of the interconnecting wire.
Locked Rotor	The rotor is locked in one position and will not turn.	Disassemble the flowmeter and remove the debris or contaminants that are holding the rotor.
Defective Bearings	The bearings have worn or corroded and will not permit the rotor to turn.	Disassemble the the flowmeter and replace the bearings.
Warped Shaft	Bearing will not rotate on shaft. Internal components are bent, broken or corroded.	Damage due to changing bearing kit. Replace shaft. Disassemble flow-meter and replace broken parts.

ZERO OUTPUT (continued)

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
Low Flow	Some readout units contain a low flow cutoff (usually set for 5 or 25 Hz and the unit will not provide an output for flow below the cutoff setting.	Check the flowmeter data sheet for a low cutoff frequency.
No Flow	Some of the line valves may be closed so fluid does not pass through the flowmeter.	Check for closed valves.
Lack of Lubrication	Journal bearing parts bound together.	Use proper bearing.

7.4 INTERMITTENT OPERATION

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
Loose Electrical Connections	Connections have worked loose by vibration.	Tighten connections.
Improperly Installed Pickoff	Pickoff may become loose in housing.	Tighten pickoff.
Noise Pickup	Flowmeter signals are not being differentiated from noise.	Increase gain of preamplifier. Verify that shielding is properly grounded.
Electronic Malfunction	Flowmeter is working correctly but electronics are operating erratically.	Troubleshoot electronics.
Non-ferrous Rotor Materials	Drift in electronics.	Adjust and align electronics.
High Temperature Pickoff	Fluid temperature exceeds range of pickoff.	Replace with proper pickoff.
High Temperature Electronics	Electronics are heat sensitive.	Relocate the electronics to reduce temperature to an acceptable level.
Bearings	Bearings are worn, broken, corroded, or contaminated.	Replace bearings and recalibrate.
Uneven Flow	Flow surging or pulsating.	Increase system back pressure or provide damping.

7.5 NON-REPEATABLE METER

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
Bearings	Bearings are worn, broken, corroded, or contaminated.	Clean or replace bearings and recalibrate.
Cavitation (Liquid Meters Only)	A portion of the fluid vaporizes as it passes through the meter and again liquifies downstream.	Increase back pressure.
Loose Electrical Connections	Connections have worked loose by vibration.	Tighten connections.
Improperly Installed Pickoff	Pickoff may become loose in housing.	Tighten pickoff.
Noise Pickup	Flowmeter signals are not being differentiated from noise.	Increase gain of preamplifier. Verify that shielding is properly grounded.
Electronic Malfunction	Flowmeter is working correctly but electronics are operating erratically.	Troubleshoot electronics.
Flow conditions	Non-constant flow velocity profile or swirl is present in flow stream.	Condition flow properly. Use flow straighteners.

7.6 CONSTANT METER OUTPUT

PROBABLE CAUSE	OPERATING CONDITIONS	CORRECTIVE ACTION
RF Amplifier to meter mismatch.	Pickoff and preamplifier mismatch provides constant non-zero output due to oscillation of RF circuit.	Check data sheet. Secure proper components.
Improper Switch Position	Run/Calibrate switch on the electronics is in the calibrate position.	Set switch to the run position.
Noise	System is detecting a 60 Hz AC signal.	Check system shielding, ground, and gain adjustment.

8.0 PARTS LIST

The following pages contain a detailed listing of the turbine flowmeter parts referenced in this manual. Information from the list must be used when contacting the factory for repairs, ordering spare parts, or any questions in reference to the turbine flowmeters.

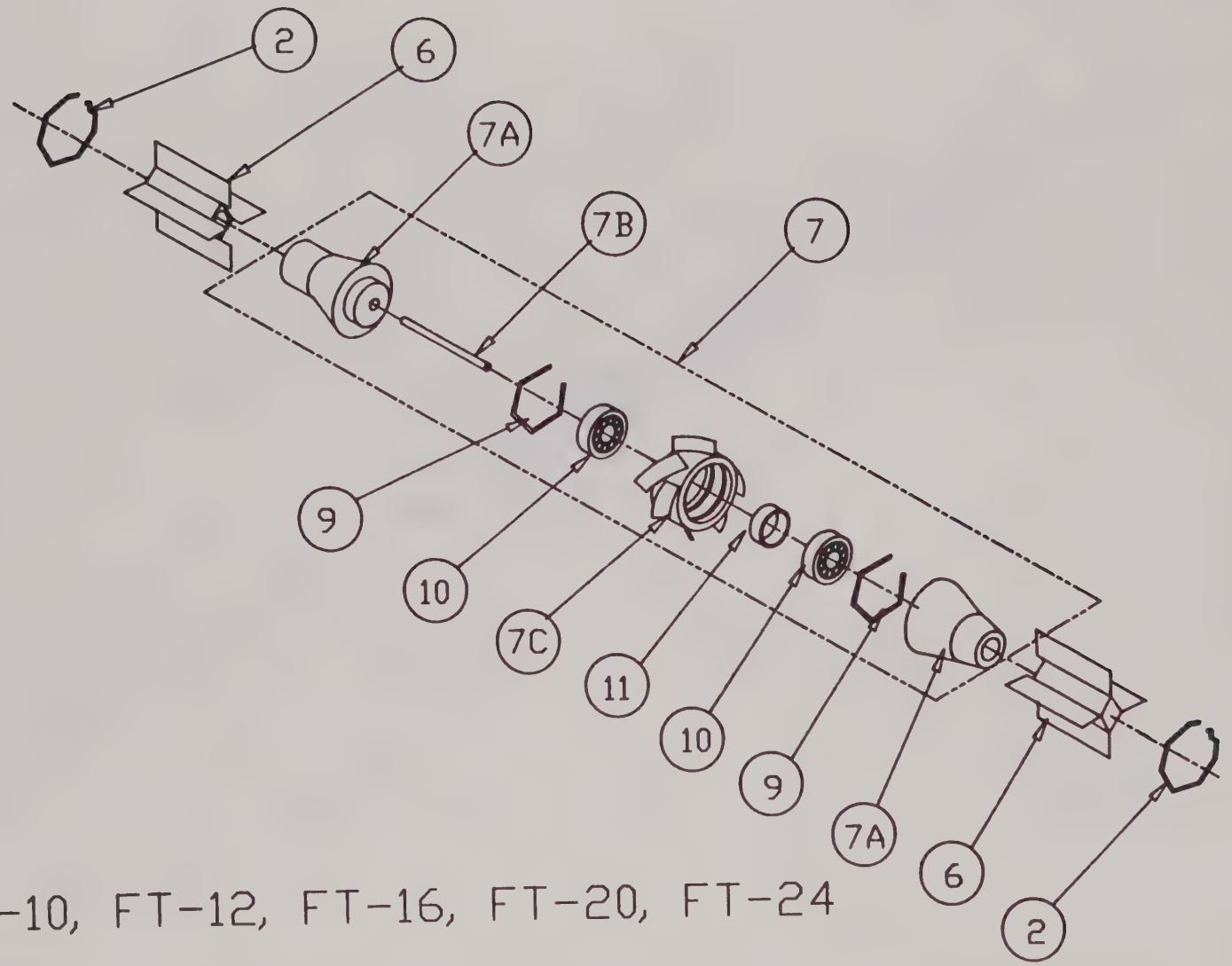
Refer to Figure 18, Illustrated Parts Breakdown, for visual identification of the various components of the flowmeters.

The letter abreviations for the different bearings are defined as follows:

_A - Ball Bearing
L_E - Liquid Journal Graphite
L_D - Liquid Journal Carbide
G_E - Gas Graphite Journal

FIGURE 7

FIGURE 8



FT-10, FT-12, FT-16, FT-20, FT-24

FIGURE 9

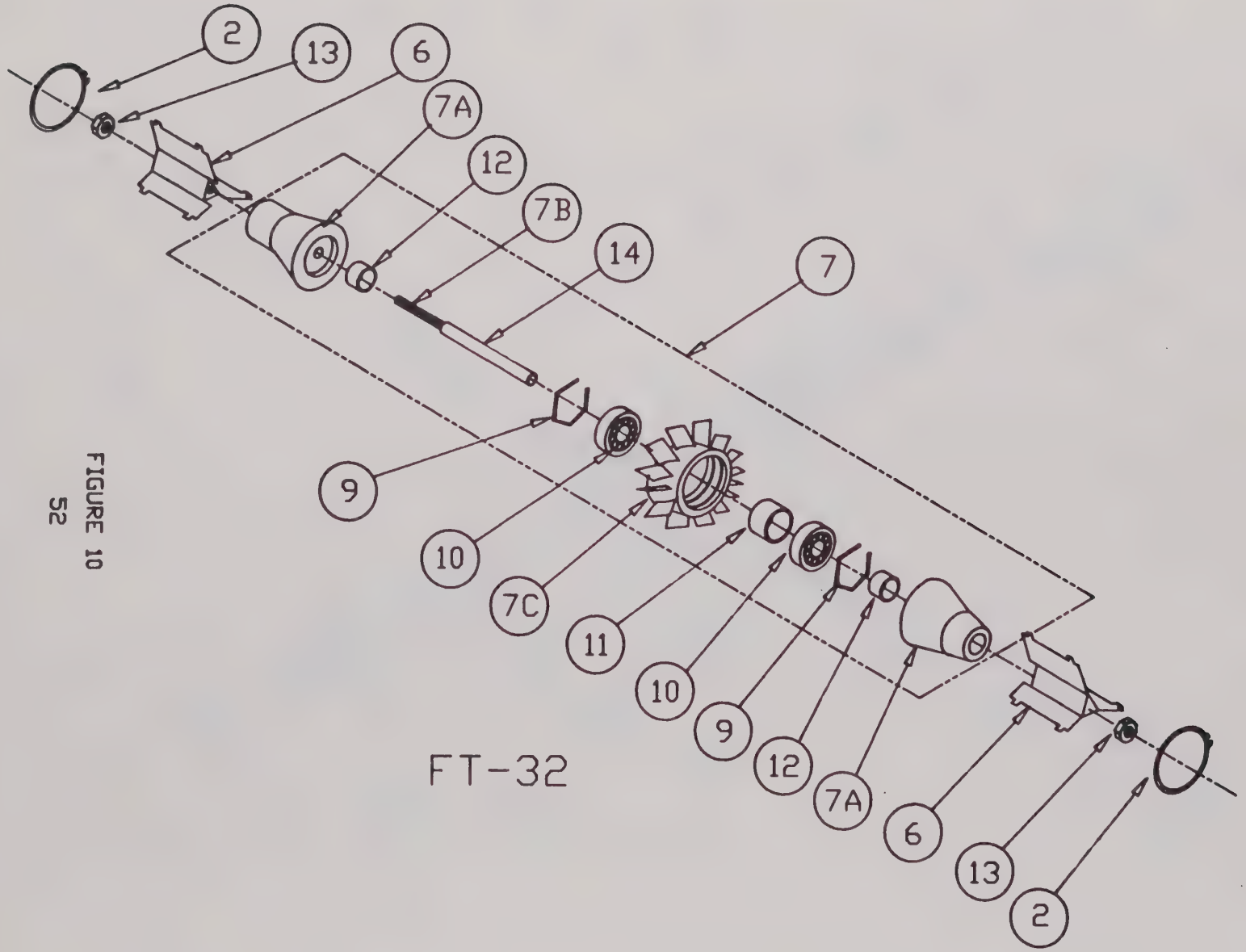


FIGURE 10
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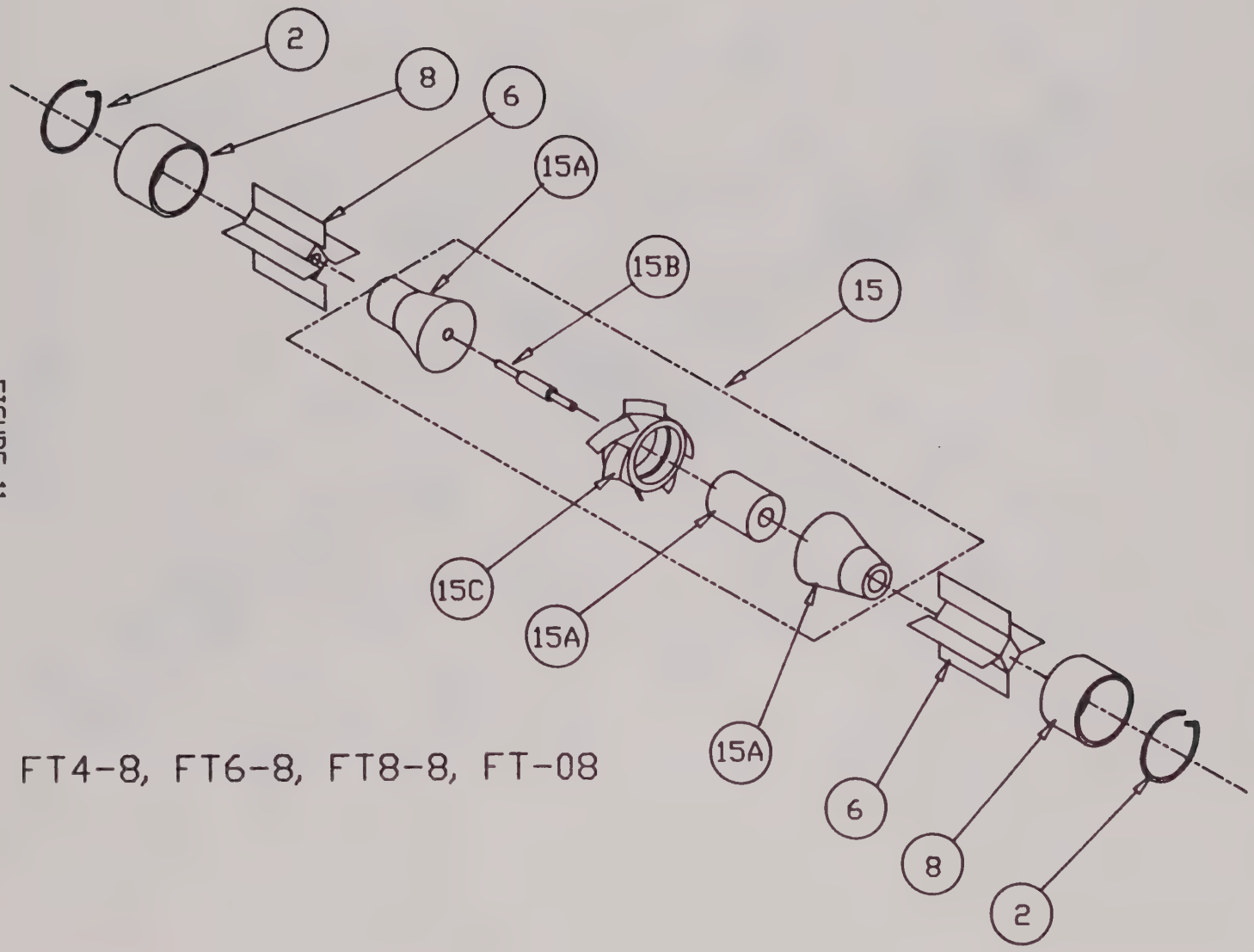
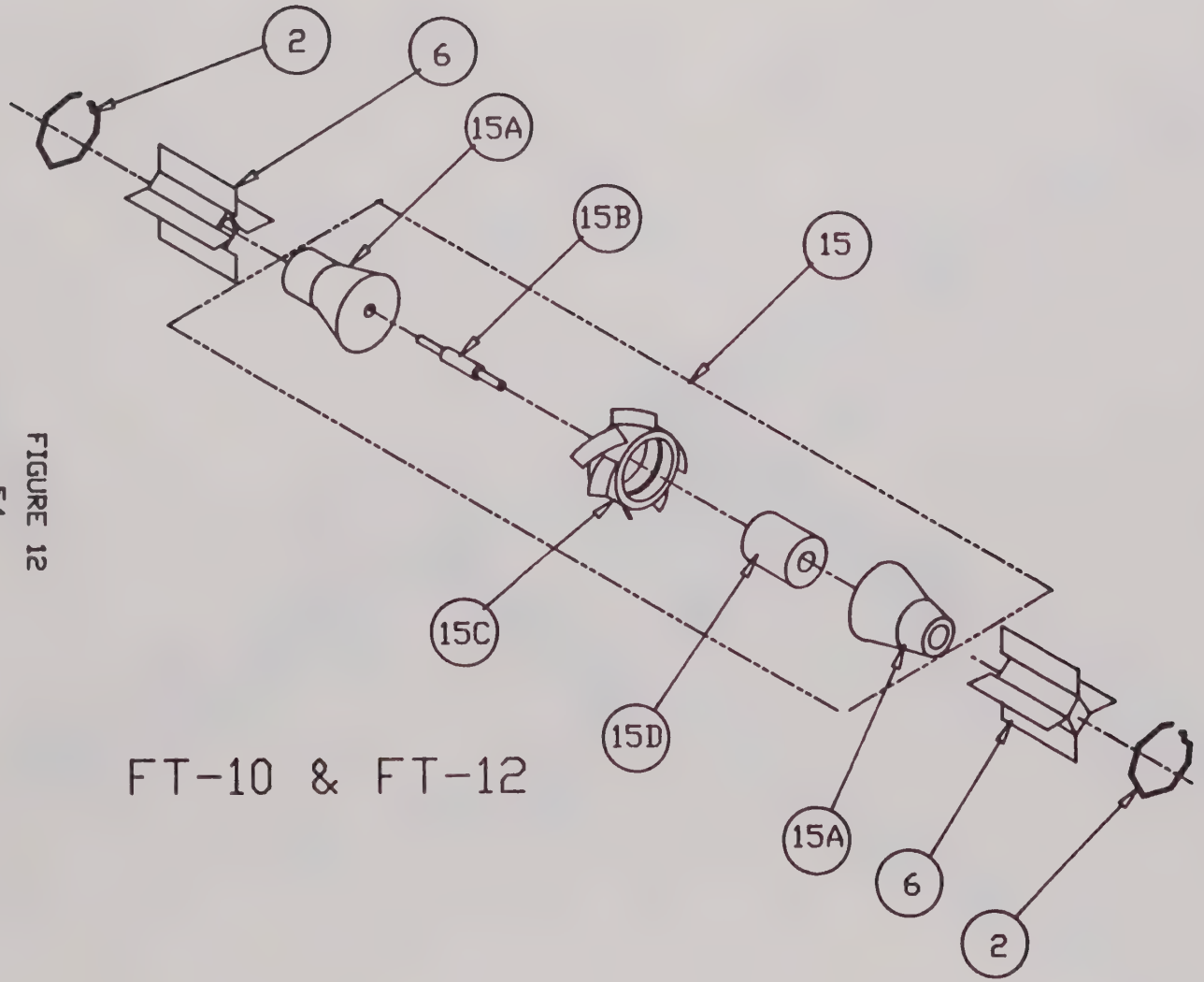


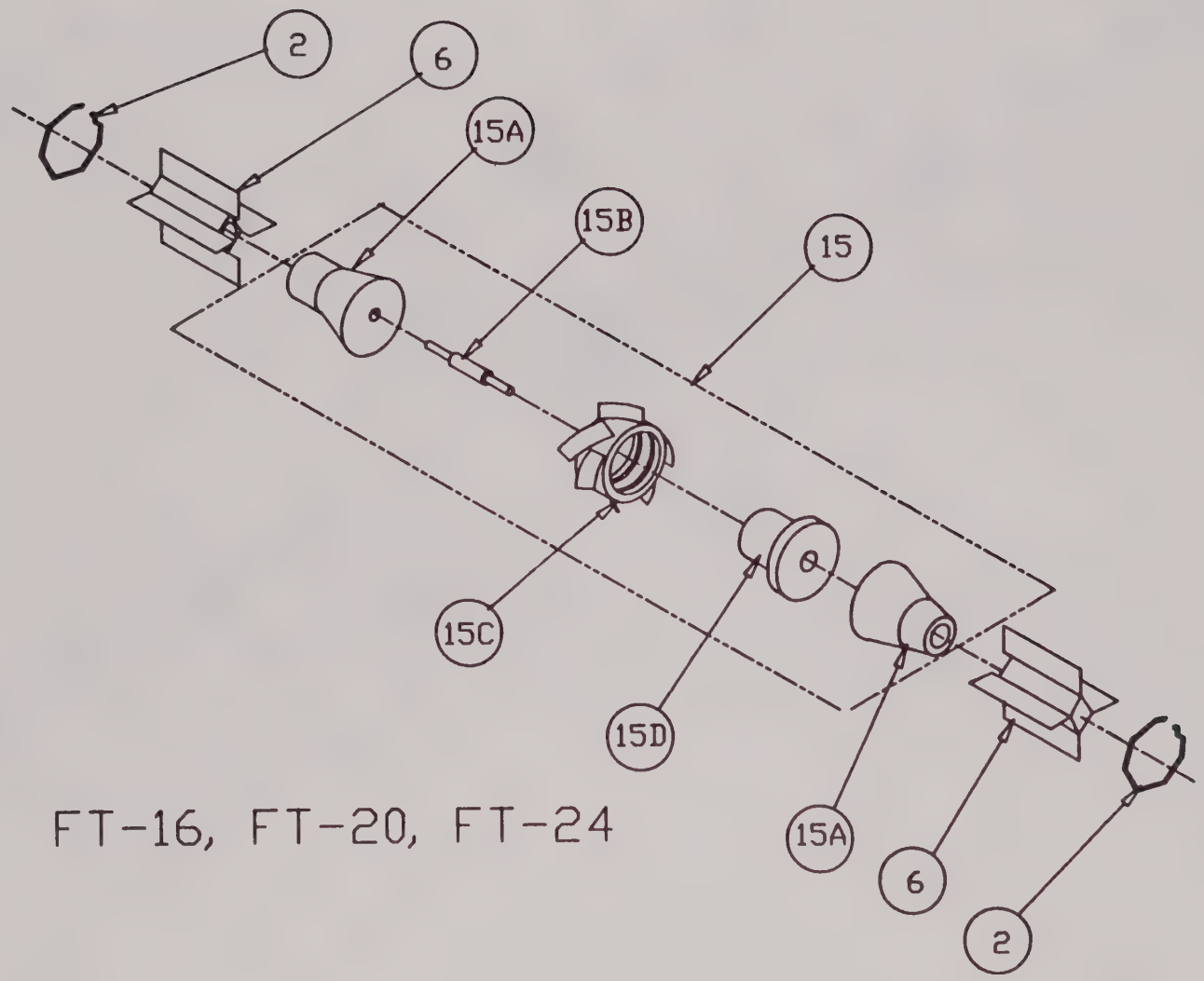
FT4-8, FT6-8, FT8-8, FT-08

FIGURE 11
53



FT-10 & FT-12

FIGURE 12
54



FT-16, FT-20, FT-24

FIGURE 13
55

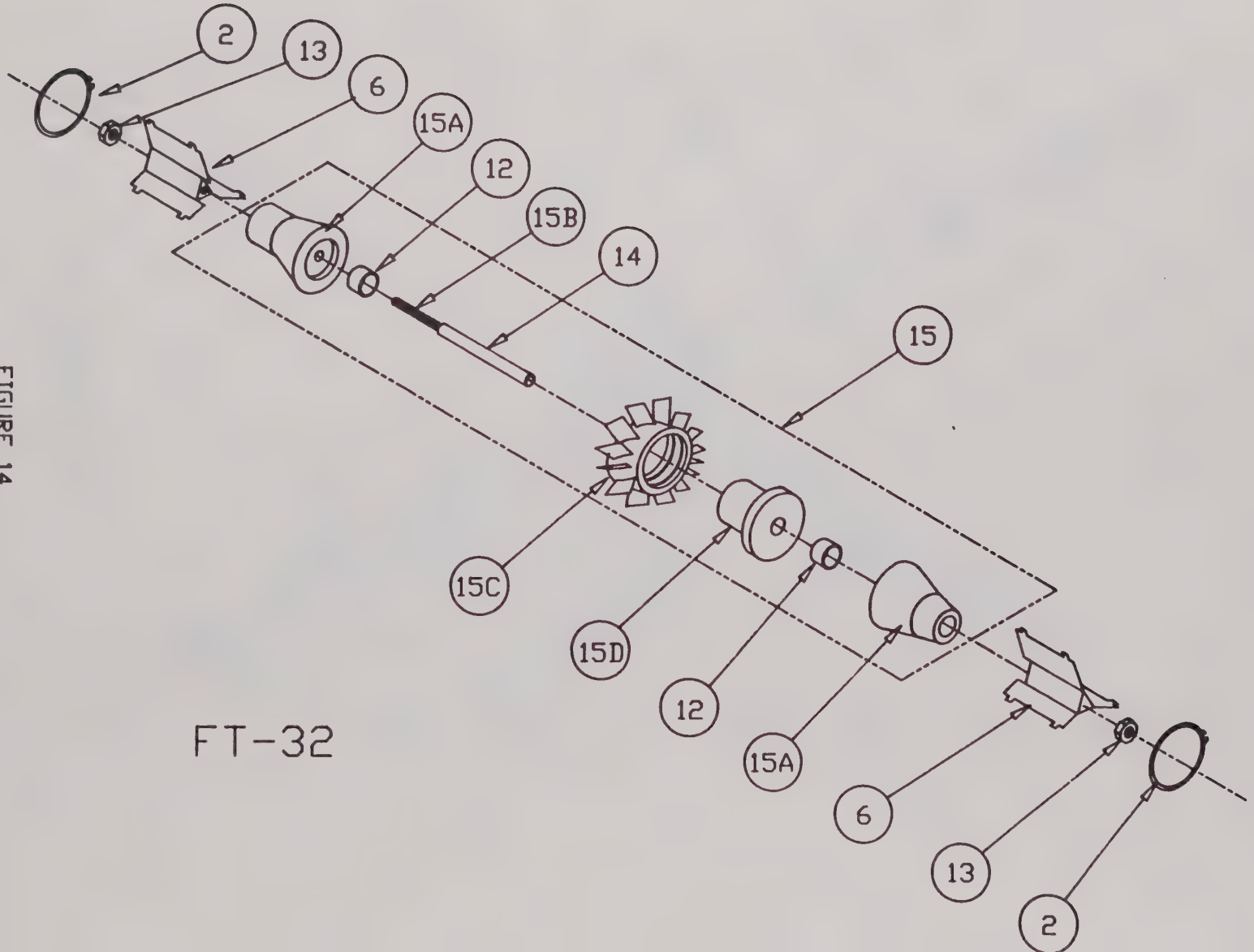
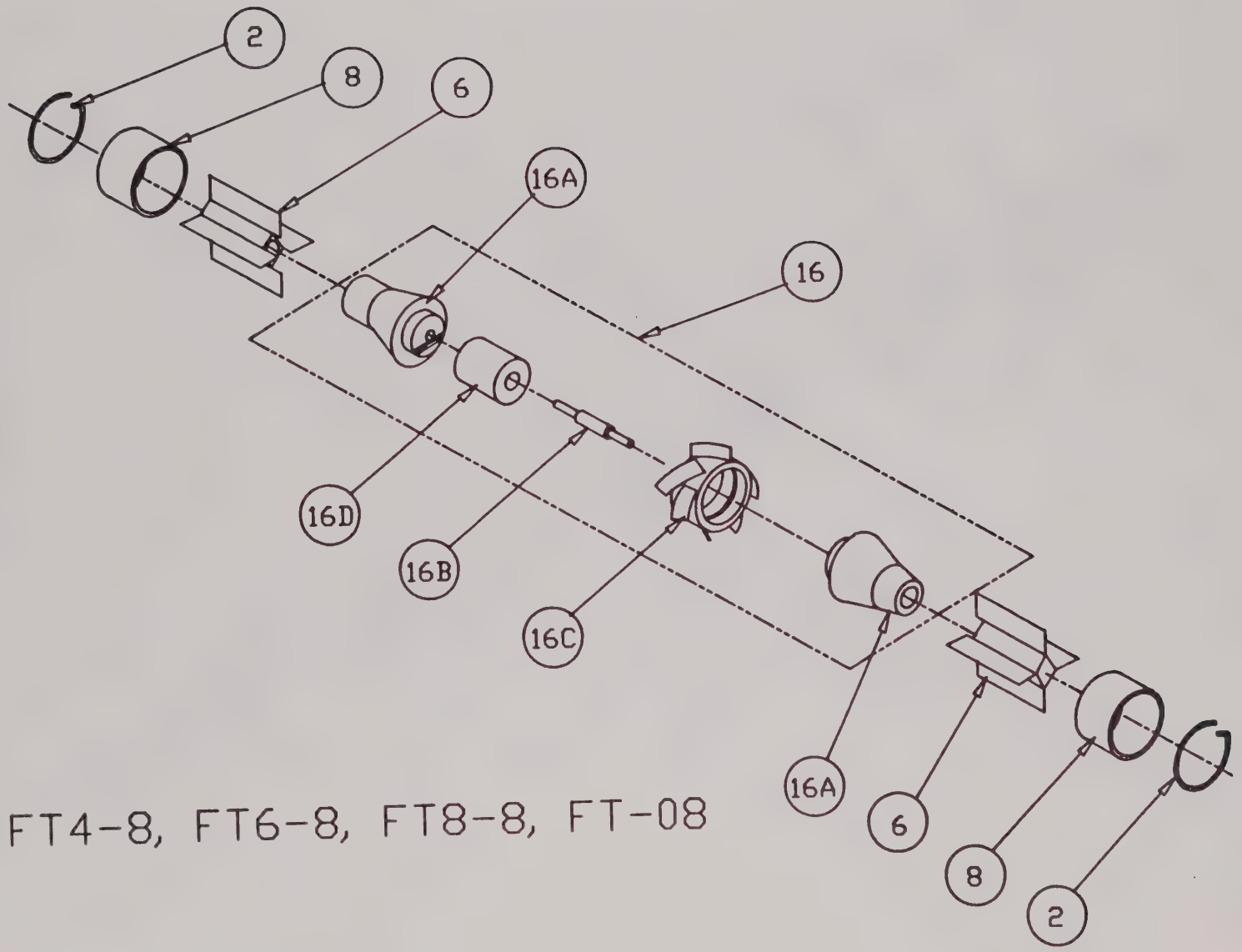
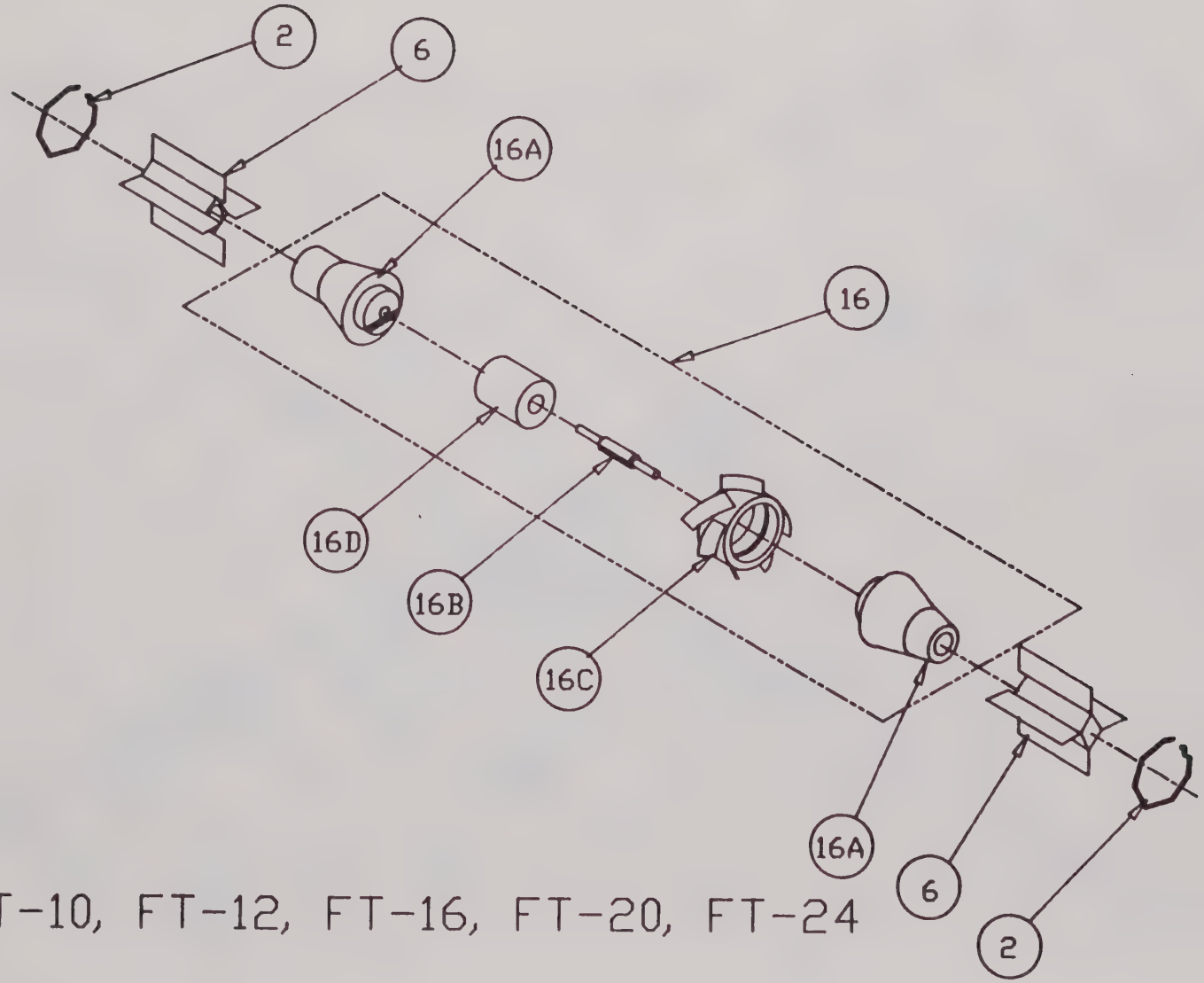


FIGURE 14
56



FT4-8, FT6-8, FT8-8, FT-08

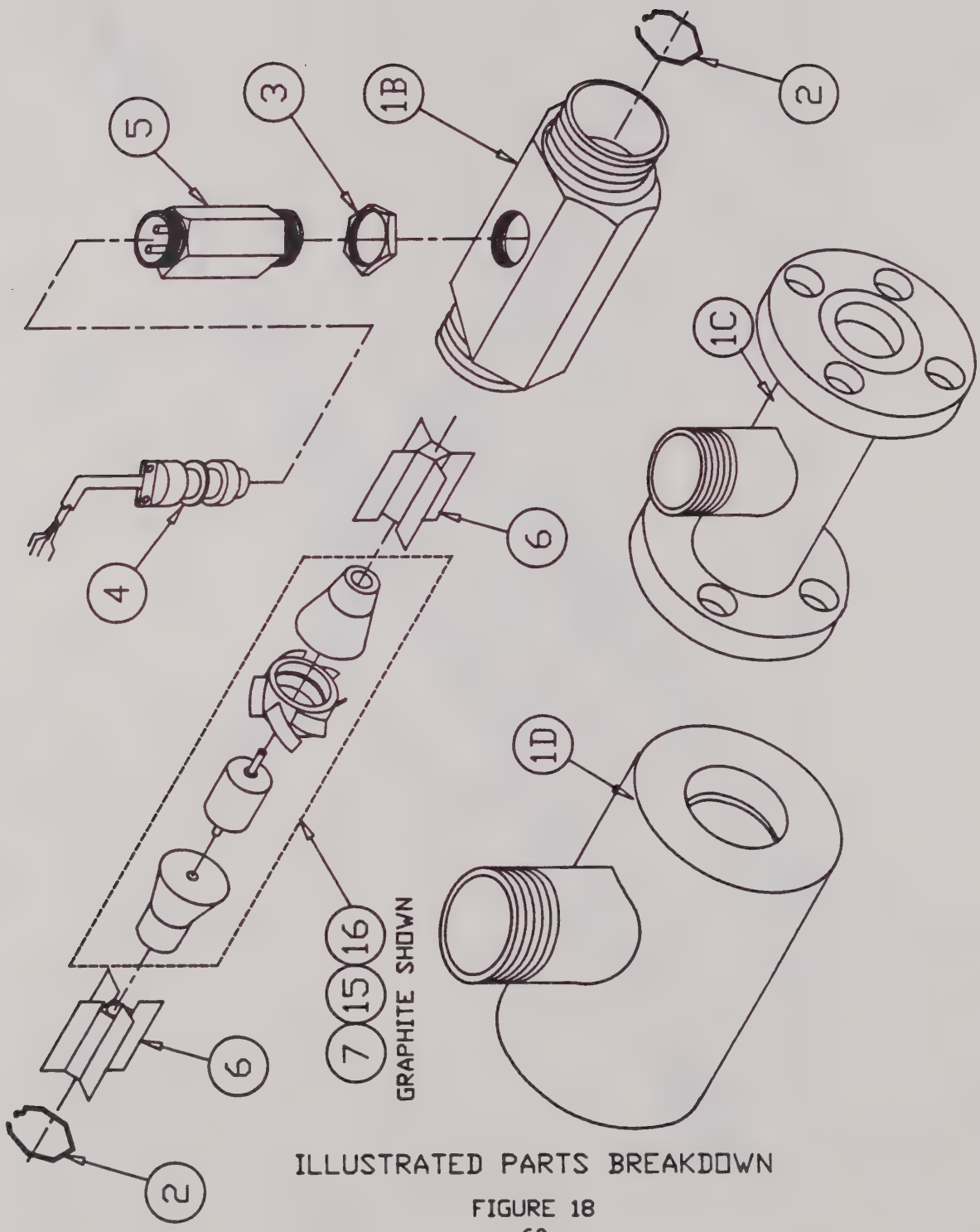
FIGURE 15



FT-10, FT-12, FT-16, FT-20, FT-24

FIGURE 16

FIGURE 17



ILLUSTRATED PARTS BREAKDOWN

FIGURE 18

LIQUID SERVICE TURBINE FLOWMETERS PARTS LIST

ITEM	DESCRIPTION	QTY	FT 4-8	FT 6-8
1	Housing, Flowmeter	1		
	a. MS		13-30837-01	13-31514-02
	b. NPT		13-31314-04	13-31314-01
	c. Flanged		13-85778-XXX	13-85779-XXX
	d. Wafer		13-82869-03	13-82869-06
2	Retaining Ring	2	57-11235-01	57-31648-02
3	Locknut, Pickoff	1	46-10036-01	46-10036-01
4	Connector, MS Pickoff	1	15-12070-01	15-12070-01
5	Pickoff	1		
	a. Magnetic Reluctance		27-30880-101	27-30880-101
	b. Modulated Carrier(RF)		27-31199-101	27-31199-101
	c. Mag, Reluct, X-proof		27-30931-102	27-30931-102
	d. RF X-Proof		27-31949-101	27-31949-101
6	Supports	2		
	a. MS		54-11702-44	54-11702-43
	b. NPT		54-11702-44	54-11702-43
	c. Flanged		54-11702-44	54-11702-43
	d. Wafer		54-11702-81	54-80956-06
		REFER TO:	FIGURE 7	FIGURE 8
7	Rotating Assembly, Ball Bearing	1	53-84921-XX	53-84922-XX
7A	Cones	2	55-11703-14	55-11703-01
7B	Shaft	1	52-11234-03	52-10907-14
	Rotor Assembly	1	53-84442-XX	53-30896-XX
7C	Rotor	1	53-84219-XX	53-31166-XX
9,10,11	Ball Bearing Replacement Kit	1	02-17413-102	02-17414-101
		REFER TO:	FIGURE 11	FIGURE 11
15	Rotating Assembly, Liquid Journal Graphite	1	53-84897-101	53-84903-101
		REFER TO:	FIGURE 15	FIGURE 15
16	Rotating Assembly, Liquid Journal Carbide	1	53-84898-101	53-84904-101
8	Spacers, Support *	2	41-84900-01	53-84900-02

XX = Rotor Configuration at shipment
XXX = Flange Size
* FT 4-8, 6-8, 8-8 and FT-08 FLANGED meters require support spacers between the retaining rings and rotor supports to properly position rotor in housing.

LIQUID SERVICE TURBINE FLOWMETERS PARTS LIST

ITEM	DESCRIPTION	QTY	FT8-8	FT-08
1	Housing, Flowmeter	1		
	a. MS		13-31514-01	13-31219-01
	b. NPT		13-31314-02	13-31314-03
	c. Flanged		13-85780-XXX	13-85781-XXX
	d. Wafer		13-82869-09	13-82869-12
2	Retaining Ring	2	57-31648-01	57-31648-03
3	Locknut, Pickoff	1	46-10036-01	46-10036-01
4	Connector, MS Pickoff	1	15-12070-01	15-12070-01
5	Pickoff	1		
	a. Magnetic Reluctance		27-30880-101	27-30880-101
	b. Modulated Carrier(RF)		27-31199-101	27-31199-101
	c. Mag, Reluct, X-proof		27-30931-102	27-30931-102
	d. RF X-Proof		27-31949-101	27-31949-101
6	Supports	2		
	a. MS		54-11702-40	54-11702-41
	b. NPT		54-11702-40	54-11702-41
	c. Flanged		54-11702-40	54-11702-41
	d. Wafer		54-80956-05	54-80956-04
	REFER TO:		FIGURE 8	FIGURE 8
7	Rotating Assembly, Ball Bearing	1	53-84923-XX	53-84924-XX
7A	Cones	2	55-11703-05	55-11703-05
7B	Shaft	1	52-10907-14	52-10907-14
	Rotor Assembly	1	53-30896-XX	53-30896-XX
7C	Rotor	1	53-31677-XX	53-31166-XX
9,10,11	Ball Bearing Replacement Kit	1	02-17414-101	02-17414-101
	REFER TO:		FIGURE 11	FIGURE 11
15	Rotating Assembly, Liquid Journal Graphite	1	53-84905-101	53-84907-101
	REFER TO:		FIGURE 15	FIGURE 15
16	Rotating Assembly, Liquid Journal Carbide	1	53-84906-101	53-84908-101
8	Spacers, Support *	2	53-84900-03	53-84900-04

XX = Rotor Configuration at shipment
XXX = Flange Size
* FT 4-8, 6-8, 8-8 & FT-08 FLANGED meters require support spacer between the retaining rings and rotor supports to properly position rotor in housing.

LIQUID SERVICE TURBINE FLOWMETERS PARTS LIST

ITEM	DESCRIPTION	QTY	FT-10	FT-12
1	Housing, Flowmeter	1		
	a. MS		13-30884-01	13-30877-01
	b. NPT		13-51275-01	13-51044-01
	c. Flanged		13-85782-XXX	13-85783-XXX
	d. Wafer		13-82869-15	13-82869-18
2	Retaining Ring	2	57-11748-03	57-11728-03
3	Locknut, Pickoff	1	46-10036-01	46-10036-01
4	Connector, MS Pickoff	1	15-12070-01	15-12070-01
5	Pickoff	1		
	a. Magnetic Reluctance		27-30880-101	27-30880-101
	b. Modulated Carrier(RF)		27-31199-101	27-31199-101
	c. Mag, Reluct, X-proof		27-30931-102	27-30931-102
	d. RF X-Proof		27-31949-101	27-31949-101
6	Supports	2		
	a. MS		[1] 54-82282-01	54-31333-08
	b. NPT		[1] 54-82282-01	54-31333-08
	c. Flanged		[1] 54-82282-01	54-31333-08
	d. Wafer		[2] 54-82282-04	54-31333-13
	REFER TO:		FIGURE 9	FIGURE 9
7	Rotating Assembly, Ball Bearing	1	53-84925-XX	[3] 53-84926-XX
7A	Cones	2	54-82282-01	55-31334-02
7B	Shaft	1	52-10182-09	52-10182-09
	Rotor Assembly	1	53-30888-XX	53-30895-XX
7C	Rotor	1	53-31167-XX	53-31168-XX
9,10,11	Ball Bearing Replacement Kit	1	02-17415-101	02-17415-101
	REFER TO:		FIGURE 12	FIGURE 12
15	Rotating Assembly, Liquid Journal Graphite	1	53-84909-101	53-84911-101
	REFER TO:		FIGURE 16	FIGURE 16
16	Rotating Assembly, Liquid Journal Carbide	1	53-84910-101	53-84912-101
8	Spacers, Support	2	N/A	N/A

XX = Rotor Configuration at shipment
XXX = Flange Size

[1] -01 ball brg -02 jnl graph -03 carb
[2] -04 ball brg -05 jnl graph -06 carb
[3] For service to 25 GPM consult factory

LIQUID SERVICE TURBINE FLOWMETERS PARTS LIST

ITEM	DESCRIPTION	QTY	FT-16	FT-20
1	Housing, Flowmeter	1		
	a. MS		13-80024-01	13-80023-01
	b. NPT		13-80024-03	13-80023-03
	c. Flanged		13-85784-XXX	13-85785-XXX
	d. Wafer		13-82869-21	12-82869-24
2	Retaining Ring	2	57-17153-01	57-17154-01
3	Locknut, Pickoff	1	46-10036-01	46-10036-01
4	Connector, MS Pickoff	1	15-12070-01	15-12070-01
5	Pickoff	1		
	a. Magnetic Reluctance		27-30880-101	27-30880-101
	b. Modulated Carrier(RF)		27-31199-101	27-31199-101
	c. Mag, Reluct, X-proof		27-30931-102	27-30931-102
	d. RF X-Proof		27-31949-101	27-31949-101
6	Supports	2		
	a. MS		54-31194-20	54-31623-10
	b. NPT		54-31194-20	54-31623-10
	c. Flanged		54-31194-20	54-31623-10
	d. Wafer		54-31194-21	54-31623-11
	REFER TO:		FIGURE 9	FIGURE 9
7	Rotating Assembly, Ball Bearing	1	53-84927-XX	53-84928-XX
7A	Cones	2	55-11710-03	55-11710-03
7B	Shaft	1	52-13152-1-13	52-13152-1-13
	Rotor Assembly	1	53-30023-XX	53-30947-XX
7C	Rotor	1	53-31169-XX	53-31170-XX
9,10,11	Ball Bearing Replacement Kit	1	02-17416-101	02-17416-101
	REFER TO:		FIGURE 13	FIGURE 13
15	Rotating Assembly, Liquid Journal Graphite	1	53-84913-101	53-84915-101
	REFER TO:		FIGURE 16	FIGURE 16
16	Rotating Assembly, Liquid Journal Carbide	1	53-84914-101	53-84916-101
8	Spacers, Support *	2	N/A	N/A

XX = Rotor Configuration at shipment
XXX = Flange Size

LIQUID SERVICE TURBINE FLOWMETERS PARTS LIST

ITEM	DESCRIPTION	QTY	FT-24	FT-32
1	Housing, Flowmeter	1		
	a. MS		13-51892-01	13-51871-01
	b. NPT		13-51930-01	13-51870-01
	c. Flanged		13-85786-XXX	13-85787-XXX
	d. Wafer		13-82869-27	13-82869-30
2	Retaining Ring	2	57-31920-03	57-31920-04
3	Locknut, Pickoff	1	46-10036-01	46-10036-01
4	Connector, MS Pickoff	1	15-12070-01	15-12070-01
5	Pickoff	1		
	a. Magnetic Reluctance		27-30880-101	27-30880-101
	b. Modulated Carrier(RF)		27-31199-101	27-31199-101
	c. Mag, Reluct, X-proof		27-30931-102	27-30931-102
	d. RF X-Proof		27-31949-101	27-31949-101
6	Supports	2		
	a. MS		54-51931-06	[4] 54-85603-101
	b. NPT		54-51931-06	[4] 54-85603-101
	c. Flanged		54-51931-06	[4] 54-85603-101
	d. Wafer		N/A	N/A
		REFER TO:	FIGURE 9	FIGURE 10
7	Rotating Assembly, Ball Bearing	1	53-84929-XX	53-84930-XX
7A	Cones	2	55-11820-04	[4] 55-85605-01
7B	Shaft	1	52-13152-2-17	[4] 52-85608-01
	Rotor Assembly	1	53-30037-XX	53-30030-XX
7C	Rotor	1	53-31171-XX	53-31172-XX
9,10,11	Ball Bearing Replacement Kit	1	02-17417-101	02-17417-101
		REFER TO:	FIGURE 13	FIGURE 14
15	Rotating Assembly, Liquid Journal Graphite	1	53-84917-101	53-84919-101
		REFER TO:	FIGURE 16	FIGURE 17
16	Rotating Assembly, Liquid Journal Carbide	1	53-84918-101	53-84920-101
8	Spacers, Support	2	N/A	N/A

XX = Rotor Configuration at shipment
XXX = Flange Size
[4] For FT-32 meters with S/N 3201250 and up.
For below 320150, consult factory.

GAS SERVICE TURBINE FLOWMETERS PARTS LIST

ITEM	DESCRIPTION	QTY	FT 2-8	FT 4-8
1	Housing, Flowmeter	1		
	a. MS		13-86374-109	13-86374-106
	b. NPT		13-86374-110	13-86374-107
	c. Flanged		13-86374-111	13-86374-108
	d. Wafer		13-86374-152	13-86374-151
2	Retaining Ring	2	57-31648-02	57-11235-01
3	Locknut, Pickoff	1	46-10036-01	46-10036-01
4	Connector, MS Pickoff	1	15-12070-01	15-12070-01
5	Pickoff	1		
	a. Magnetic Reluctance		27-30880-101	27-30880-101
	b. Modulated Carrier(RF)		27-31199-101	27-31199-101
	c. Mag, Reluct, X-proof		27-30931-102	27-30931-102
	d. RF X-Proof		27-31949-101	27-31949-101
6	Supports	2		
	a. MS		54-11702-43	54-11702-44
	b. NPT		54-11702-43	54-11702-44
	c. Flanged		54-11702-43	54-11702-44
	d. Wafer		54-80956-06	54-11702-81
	REFER TO:		FIGURE 8	FIGURE 7
7	Rotating Assembly, Ball Bearing	1	53-84922-103	53-84921-XX
7A	Cones	2	55-11703-01	55-11703-14
7B	Shaft	1	52-10907-14	52-11234-03
	Rotor Assembly	1	53-30896-XX	53-84442-XX
7C	Rotor	1	53-31166-XX	53-84219-XX
9,10,11	Ball Bearing Replacement Kit	1	02-17414-101	02-17413-103
15	Rotating Assembly, Gas Graphite Journal	1	N/A	[5]
16	Rotating Assembly, Liquid Journal Carbide	1	N/A	N/A
8	Spacers, Support *	2	41-84900-02	41-84900-01

XX = Rotor Configuration at shipment
XXX = Flange Size
* FT 2-8, 4-8, 6-8, 8-8 and FT-08 FLANGED meters require support spacers between the retaining rings and rotor supports to properly position rotor in housing.
[5] With Engineering Approval.

GAS SERVICE TURBINE FLOWMETERS PARTS LIST

ITEM	DESCRIPTION	QTY	FT-6-8	FT 8-8
1	Housing, Flowmeter	1		
	a. MS		13-86374-109	13-86374-112
	b. NPT		13-86374-110	13-86374-113
	c. Flanged		13-86374-111	13-86374-114
	d. Wafer		13-86374-152	13-86374-153
2	Retaining Ring	2	57-31648-02	57-31648-01
3	Locknut, Pickoff	1	46-10036-01	46-10036-01
4	Connector, MS Pickoff	1	15-12070-01	15-12070-01
5	Pickoff	1		
	a. Magnetic Reluctance		27-30880-101	27-30880-101
	b. Modulated Carrier(RF)		27-31199-101	27-31199-101
	c. Mag, Reluct, X-proof		27-30931-102	27-30931-102
	d. RF X-Proof		27-31949-101	27-31949-101
6	Supports	2		
	a. MS		54-11702-43	54-11702-40
	b. NPT		54-11702-43	54-11702-40
	c. Flanged		54-11702-43	54-11702-40
	d. Wafer		54-80956-06	54-80956-05
	REFER TO:		FIGURE 8	FIGURE 8
7	Rotating Assembly, Ball Bearing	1	53-84922-XX	53-84923-XX
7A	Cones	2	55-11703-01	55-11703-05
7B	Shaft	1	52-10907-14	52-10907-14
	Rotor Assembly	1	53-30896-XX	53-30896-XX
7C	Rotor	1	53-31666-XX	53-31677-XX
9,10,11	Ball Bearing Replacement Kit	1	02-17414-101	02-17414-101
15	Rotating Assembly, Gas Graphite Journal	1	[5]	[5]
16	Rotating Assembly, Liquid Journal Carbide	1	N/A	N/A
8	Spacers, Support *	2	53-84900-02	53-84990-03

XX = Rotor Configuration at shipment
XXX = Flange Size
* FT 2-8, 4-8, 6-8, 8-8 and FT-08 FLANGED meters require support spacers between the retaining rings and rotor supports to properly position rotor in housing.
[5] With Engineering Approval.

GAS SERVICE TURBINE FLOWMETERS PARTS LIST

ITEM	DESCRIPTION	QTY	FT-08	FT-10
1	Housing, Flowmeter	1		
	a. MS		13-86374-115	13-86374-118
	b. NPT		13-86374-116	13-86374-119
	c. Flanged		13-86374-117	13-86374-120
	d. Wafer		13-86374-154	13-86374-155
2	Retaining Ring	2	57-31648-03	57-11728-03
3	Locknut, Pickoff	1	46-10036-01	46-10036-01
4	Connector, MS Pickoff	1	15-12070-01	15-12070-01
5	Pickoff	1		
	a. Magnetic Reluctance		27-30880-101	27-30880-101
	b. Modulated Carrier(RF)		27-31199-101	27-31199-101
	c. Mag, Reluct, X-proof		27-30931-102	27-30931-102
	d. RF X-Proof		27-31949-101	27-31949-101
6	Supports	2		
	a. MS		54-11702-41	54-82282-01
	b. NPT		54-11702-41	54-82282-01
	c. Flanged		54-11702-41	54-82282-01
	d. Wafer		54-80956-04	54-82282-04
	REFER TO:		FIGURE 8	FIGURE 9
7	Rotating Assembly, Ball Bearing	1	53-84924-XX	53-84925-XX
7A	Cones	2	55-11703-05	54-82282-01
7B	Shaft	1	52-10907-14	52-10182-09
	Rotor Assembly	1	53-30896-XX	53-30888-XX
7C	Rotor	1	53-31166-XX	53-31167-XX
9,10,11	Ball Bearing Replacement Kit	1	02-17414-101	02-17415-101
15	Rotating Assembly, Gas Journal Graphite	1	[5]	[5]
16	Rotating Assembly, Liquid Journal Carbide	1	N/A	N/A
8	Spacers, Support *	2	53-84900-04	N/A

XX = Rotor Configuration at shipment
XXX = Flange Size
* FT 2-8, 4-8, 6-8, 8-8 and FT-08 FLANGED meters require support spacers between the retaining rings and rotor supports to properly position rotor in housing.
[5] With Engineering Approval.

GAS SERVICE TURBINE FLOWMETERS PARTS LIST

ITEM	DESCRIPTION	QTY	FT-12	FT-16
1	Housing, Flowmeter	1		
	a. MS		13-86374-121	13-86374-124
	b. NPT		13-86374-122	13-86374-125
	c. Flanged		13-86374-123	13-86374-126
	d. Wafer		13-86374-156	13-86374-157
2	Retaining Ring	2	57-11728-03	57-17153-01
3	Locknut, Pickoff	1	46-10036-01	46-10036-01
4	Connector, MS Pickoff	1	15-12070-01	15-12070-01
5	Pickoff	1		
	a. Magnetic Reluctance		27-30880-101	27-30880-101
	b. Modulated Carrier(RF)		27-31199-101	27-31199-101
	c. Mag, Reluct, X-proof		27-30931-102	27-30931-102
	d. RF X-Proof		27-31949-101	27-31949-101
6	Supports	2		
	a. MS		54-31333-08	54-31194-20
	b. NPT		54-31333-08	54-31194-20
	c. Flanged		54-31333-08	54-31194-20
	d. Wafer		54-31333-13	54-31194-21
	REFER TO:		FIGURE 9	FIGURE 9
7	Rotating Assembly, Ball Bearing	1	53-84926-XX	53-84927-XX
7A	Cones	2	55-31334-02	55-11710-03
7B	Shaft	1	52-10182-09	52-13152-1-13
	Rotor Assembly	1	53-30895-XX	53-30023-XX
7C	Rotor	1	53-31168-XX	53-31169-XX
9,10,11	Ball Bearing Replacement Kit	1	02-17415-101	02-17416-101
15	Rotating Assembly, Gas Journal Graphite	1	[5]	[5]
16	Rotating Assembly, Liquid Journal Carbide	1	N/A	N/A
8	Spacers, Support	2	N/A	N/A

XX = Rotor Configuration at shipment
XXX = Flange Size

[5] With Engineering Approval.

GAS SERVICE TURBINE FLOWMETERS PARTS LIST

ITEM	DESCRIPTION	QTY	FT-20	FT-24
1	Housing, Flowmeter	1		
	a. MS		13-86374-127	13-86374-130
	b. NPT		13-86374-128	13-86374-131
	c. Flanged		13-86374-129	13-86374-132
	d. Wafer		13-86374-158	13-86374-159
2	Retaining Ring	2	57-17154-01	57-31920-03
3	Locknut, Pickoff	1	46-10036-01	46-10036-01
4	Connector, MS Pickoff	1	15-12070-01	15-12070-01
5	Pickoff	1		
	a. Magnetic Reluctance		27-30880-101	27-30880-101
	b. Modulated Carrier(RF)		27-31199-101	27-31199-101
	c. Mag, Reluct, X-proof		27-30931-102	27-30931-102
	d. RF X-Proof		27-31949-101	27-31949-101
6	Supports	2		
	a. MS		54-31623-10	54-51931-06
	b. NPT		54-31623-10	54-51931-06
	c. Flanged		54-31623-10	54-51931-06
	d. Wafer		54-31623-11	N/A
	REFER TO:		FIGURE 9	FIGURE 9
7	Rotating Assembly, Ball Bearing	1	53-84928-XX	53-84929-XX
7A	Cones	2	55-11710-03	55-11820-04
7B	Shaft	1	52-13152-1-13	52-13152-2-17
	Rotor Assembly	1	53-30947-XX	53-30037-XX
7C	Rotor	1	53-31170-XX	53-31171-XX
9,10,11	Ball Bearing Replacement Kit	1	02-17416-101	02-17417-101
15	Rotating Assembly, Gas Journal Graphite	1	[5]	[5]
16	Rotating Assembly, Liquid Journal Carbide	1	N/A	N/A
8	Spacers, Support	2	N/A	N/A

XX = Rotor Configuration at shipment
XXX = Flange Size

[5] With Engineering Approval.

GAS SERVICE TURBINE FLOWMETERS PARTS LIST

ITEM	DESCRIPTION	QTY	FT-32
1	Housing, Flowmeter	1	
	a. MS		13-86374-133
	b. NPT		13-86374-134
	c. Flanged		13-86374-135
	d. Wafer		13-86374-160
2	Retaining Ring	2	57-31920-04
3	Locknut, Pickoff	1	46-10036-01
4	Connector, MS Pickoff	1	15-12070-01
5	Pickoff	1	
	a. Magnetic Reluctance		27-30880-101
	b. Modulated Carrier(RF)		27-31199-101
	c. Mag, Reluct, X-proof		27-30931-102
	d. RF X-Proof		27-31949-101
6	Supports	2	
	a. MS		[4] 54-85603-101
	b. NPT		[4] 54-85603-101
	c. Flanged		[4] 54-85603-101
	d. Wafer		N/A
	REFER TO:		FIGURE 10
7	Rotating Assembly, Ball Bearing	1	53-84930-XX
7A	Cones	2	[4] 55-85605-01
7B	Shaft	1	[4] 52-85608-01
	Rotor Assembly	1	53-30030-XX
7C	Rotor	1	53-31172-XX
9,10,11	Ball Bearing Replacement Kit	1	02-17417-101
15	Rotating Assembly, Gas Journal Graphite	1	[5]
16	Rotating Assembly, Liquid Journal Carbide	1	N/A
8	Spacers, Support	2	N/A

XX = Rotor Configuration at shipment
XXX = Flange Size

[4] For FT-32 meters with S/N 3201250 and up.
For below 320150, consult factory.

[5] With Engineering Approval.

MP MASTER
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